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ADVANCED DISTRIBUTED SIMULATION TECHNOLOGY ADVANCED ROTARY WING AIRCRAFT

STRAWMAN VERIFICATION & VALIDATION PLAN FOR THE ARWA SIMULATOR SYSTEM

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The ADST ARWA Strawman Verification and Validation Plan was developed during Phase 1 of the ADST ARWA program and is a "living" document that will be revised to record effects of code changes and plans for validating correct implementation of modifications. The V&V plan represents has as its objective to provide a "roadmap" identifying both V&V process and information sources that will be required over the development cycle. The V&V plan outlines the specifics of the approach that will be taken to determine if components fulfill design requirements and that system elements are in compliance with functional requirements.

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to define the ARWA Simulator Verification and Validation (V&V) Plan. This V&V plan describes the activities required to verify and validate the ARWA SS.

1.2 OVERVIEW

The following provides a brief description of the major sections of this document:

Section 2 provides a summary description of the ARWA SS. Also described is the approach taken to selectively conduct V&V activities. This approach is necessary in order to use the V&V resources most effectively. V&V intensity levels and the specific activities to be performed are also defined in this section. The Configuration Management approach is discussed and the participating agencies are identified.

Section 3 defines the V&V responsibilities.

Section 4 defines the purpose and objectives of the ARWA SS. The model hierarchy is described and the intended uses of the ARWA SS are defined.

Section 5 identifies the information sources used in the development of this V&V plan.

Section 6 defines the verification activities and products for each of the ARWA components.

Section 7 defines the validation activities and products for each of the ARWA components.

Section 8 defines the accreditation plan for each of the ARWA components.

2.0 BACKGROUND

2.1 DESCRIPTION

The ARWA SS provides the capability to engage in simulated war fighting exercises within the Battlefield Distributed Simulation Development (BDS-D) environment for the purpose of rapidly exploring tactics, doctrine and combat system development issues. The ARWA SS is a real-time, software intensive, network interoperable simulation capable of supporting reconfiguration to any combination of two RAH-66 or two AH-64D. The software simulation is data driven to provide easy access to critical parameters for modification purposes in an experimentation environment. The ARWA SS consists of two (2) devices which can be individually reconfigured in various combinations of the aircraft listed above.

2.2 V&V APPROACH

The overall approach to V&V of the ARWA SS is shown in Figure 2.2-1. The METL is the Mission Essential Task List. This document defines the basic missions which the simulated aircraft must perform. The Task and Skills Analysis (TSA) uses the METL to derive the crew tasks which the pilot and co-pilot/gunner must perform in the accomplishment of the missions. The Selected Fidelity Analysis (SFA) uses the TSA and the defined purpose and expectations of the ARWA SS to define the specific functions that must be included in the ARWA SS and to what level of fidelity they must be represented. The SFA output is used by the development team together with the government furnished requirements and the ARWA SS statement of work (SOW) to define the requirements and specifications for the developers of the ARWA SS capabilities, namely Loral, Pulau, Boeing, and McDonnell Douglas Helicopter Company (MDHC).

The targets for V&V activities are

- the aforementioned ARWA simulation requirements
- the integrated ARWA SS
- the components of the ARWA SS such as the Visual System Module (VSM), the Flight Station Module (FSM), and the Simulator System Module (SSM)
- the computer software configuration items (CSCI) which comprise the above components
- the computer software components (CSC) which comprise the CSCIs
- the computer software units (CSU) which comprise the CSCs

The large number of V&V targets and the limited resources which are available for the V&V effort make it impractical to perform a complete set of V&V activities to all components of the ARWA SS. The concept of performing a subset of V&V activities to selected components was developed to ensure that all components of the ARWA SS have been considered from the V&V perspective. This concept is implemented by identifying V&V 'intensity levels.' A summary of these levels is shown in Figure 2.2-1. An expansion of these level definitions is given below.

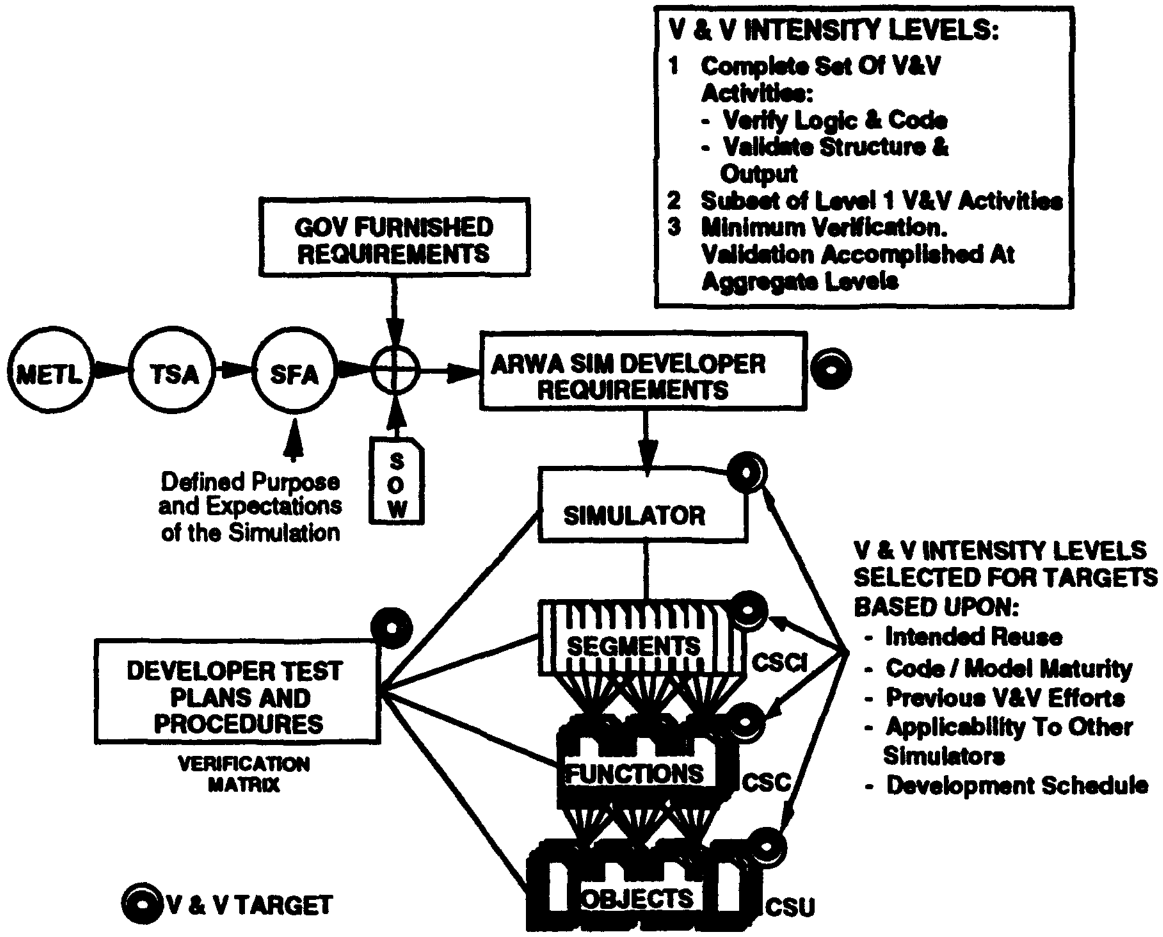

FIGURE 2.2-1 ARWA SS V&V APPROACH.

V&V Level 1

Full set of verification and validation activities must be performed. The following tasks must be completed:

- logic verification
- code verification
- structure validation
- output validation

V&V Level 2

A subset of the Level 1 activities must be performed. Automated analysis may be necessary to cover all required cases. Verification and or validation activities may be omitted, depending on previous V&V efforts, potential reuse, available resources, or schedule constraints.

V&V Level 3

Basic verification is required. Inspection of output and manual comparison to predicted results may be sufficient. Validation may be accomplished in conjunction with the validation of other components.

The selection of the V&V intensity level to apply to each ARWA SS component is based on the following criteria:

- selected fidelity of the segment
- importance of segment to overall fidelity
- code maturity and complexity
- reuse potential
- development schedule
- V&V resources

The process of assigning intensity levels to the ARWA SS segments is shown in Figure 2.2-2. This process, called criticality analysis in the figure, identifies the V&V intensity level assigned to segments. The inputs to the criticality analysis are the selected fidelity from the TSA/SFA and the applications for which the ARWA is intended. The outputs are the V&V intensity level assignments and the required ARWA SS functionality.

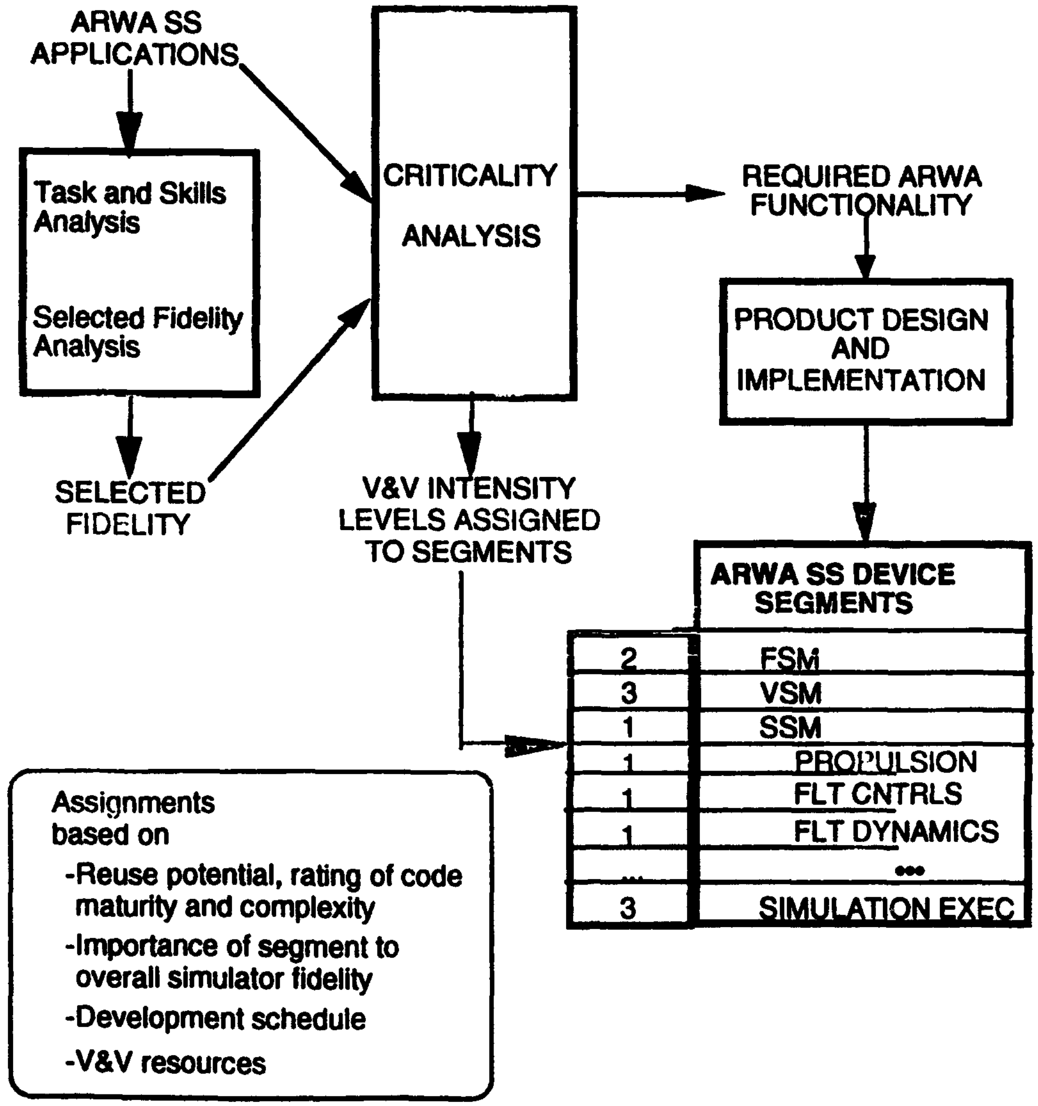

FIGURE 2.2.-2 V&V INTENSITY LEVEL ASSIGNMENT.

2.3 SUMMARY OF V&V INTENSITY LEVEL ASSIGNMENTS

The following V&V Intensity Level Assignments were made prior to the first Steering Committee meeting held October 26, 1993.

VISUAL SYSTEM MODULE (VSM)
Level: 3
Reuse: GFE hardware, COTS software. Generic, reusable software; interface module is hardware dependent. Data bases GFE; converted/generated from reusable generic format. Generic modules reused.
Code maturity: Much of Phase I is legacy code that has been used on previous programs, Phase II provides new code. CIG has completed acceptance test procedures.
Code complexity: High algorithmical, high computational, and high interface.

FLIGHT STATION MODULE (FSM) BASE (Includes Internal Bus Interface Unit)
Level: 2
Reuse: Interface software built of generic layers used by each module/segment with specific application layers for a specific module/segment.
Code maturity: Mature code that will be modified.
Code complexity: Moderate algorithmical. High number of interfaces. High computational.

SIMULATOR SYSTEM MODULE (SSM) - BASE
Level: 1
Reuse: Has high reuse potential for other aircraft in similar DIS applications.
Code maturity: Combination of reused and modified code.
Code complexity: High algorithmical and computational. Moderate interface.

SIMULATOR SYSTEM MODULE-RAH-66
Level: 2
Reuse: Reuse for other aircraft with similar or same systems. Interface documentation facilitates reusability.
Code maturity: Modified code that must be verified and validated in the ARWA SS environment.
Code complexity: Moderate algorithmical. High number of interfaces. High computational.

RAH-66 FLIGHT STATION MODULE
Level: 2
Reuse: Reuse for other aircraft with similar or same systems. Reusable, common COTS graphics engine reconfigured through selection of generic library routines; common sound generation module using data files. Reconfigurable base, controls, and displays. Data files for specific A/C subsystems, generic at high level. Interface documentation facilitates reusability.
Code maturity: Modified code that must be verified and validated in the ARWA SS environment.
Code complexity: Moderate algorithmical. High number of interfaces. High computational.

SIMULATOR SYSTEM MODULE-AH-64D

Level: 2

Reuse: Reuse for other aircraft with similar or same systems. Interface documentation facilitates reusability.

Code maturity: Modified code that must be verified and validated in the ARWA SS environment.

Code complexity: Moderate algorithmical. High number of interfaces. High computational.

AH-64D FLIGHT STATION MODULE

Level: 2

Reuse: Reuse for other aircraft with similar or same systems. Reusable, common COTS graphics engine reconfigured through selection of generic library routines; common sound generation module using data files. Reconfigurable base, controls, and displays. Data files for specific A/C subsystems, generic at high level. Interface documentation facilitates reusability.

Code maturity: Modified code that must be verified and validated in the ARWA SS environment.

Code complexity: Moderate algorithmical. High number of interfaces. High computational.

The following are support software products from the DIS BDS-D delivery order:

SESSION MANAGER S/S
OPERATIONAL AND LOGISTICS SUPPORT S/S
MISSION PLANNING S/S
AFTER ACTION REVIEW S/S
ARWA LAN S/S
DIS NETWORK MANAGER S/S
ENVIRONMENTAL SIMULATOR S/S

Level: 3

Reuse: High level of reuse for other simulators.

Code maturity: Mostly reused code; some modification for specific kits/ missions.

Code complexity: Moderate algorithmical. High number of interfaces. High computational.

A summary of the intensity level assignments to each module and submodule is shown in Table 2.3-1. This table also contains the number of source lines of code estimated for each module and the estimated number of labor hours required to accomplish the V&V activities for the assigned intensity level.

TABLE 2.3-1 INTENSITY LEVEL ASSIGNMENTS

Segment	V&V Intensity Level	Verification		Validation		SLOC	Total Labor Hours
		Logic	Code	Structure	Output		
							Note 1
Visual System Module (VSM)							
Overall	*3*						
Integration V&V					Note 2		320.0
VSM_Network_Interface	2	X	X	Note 3	Note 4	2000	66.7
VSM_User_Interface	2	X	X	Note 3	Note 4	6000	200.0
VSM_Hardware_Interface	2	X	X	Note 3,5	Note 4	10000	41.7
VSM_Resource_Manager	2	X	X	Note 3,6	Note 4	44000	183.3
Process_Scheduler	2	X	X	Note 3	Note 4	2000	66.7
OTW_Displays	3				Note 4		
Head_Tracker	3				Note 4		
Helmet_Mounted_Display	3				Note 4		
Admin_Console	3				Note 4		
Computer_Image_Generator	3				Note 4		
Flight Station Module (FSM)							
Overall	*2*						
Integration V&V					Note 7		320.0
FSM Base	2	X	X	Note 3	Note 8	10930	364.3
FSM Comanche	2	X	X	Note 3	Note 8	2000	66.7
FSM Longbow	2	X	X	Note 3	Note 8	2000	66.7
Simulation System Module (SSM Base)							
Overall	*2*						
Integration V&V					Note 9		320.0
Control	2	X	X	Note 3		3610	120.3
TNE	1	X	X	X	X	32595	2173.0
Bus Interface Unit	2	X	X	Note 3		4840	161.3
Cockpit Kit							
RAH-66 Comanche Kit							
Overall	*1*						
RAH-66 Flight Controls	1	X	X	X	X	1550	103.3
RAH-66 Nav/Comm	1	X	X	X	X	2100	140.0
RAH-66 Weapons	1	X	X	X	X	2000	133.3
RAH-66 Sensors	1	X	X	X	X	2815	187.7
RAH-66 ASE	3		X		X	2125	141.7
RAH-66 Flight Dynamics	1	X	X	X	X	5170	344.7
RAH-66 Propulsion	1	X	X	X	X	600	40.0
RAH-66 Physical Cues	1	X	X	X	X	725	48.3
RAH-66 TNE (see SSM Base)	1	X	X	X	X	0	0.0

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TABLE 2.3-1. INTENSITY LEVEL ASSIGNMENTS CONTINUED

Segment	V&V Intensity Level	Verification		Validation		SLOC	Total Labor Hours
		Logic	Code	Structure	Output		
							Note 1
Cockpit Kits							
AH-64D Longbow Kit							
Overall	*1*						
AH-64D Flight Controls	1	X	X	X	X	2080	138.7
AH-64D Nav/Comm	1	X	X	X	X	2800	186.7
AH-64D Weapons	1	X	X	X	X	4000	266.7
AH-64D Sensors	1	X	X	X	X	2240	149.3
AH-64D ASE	3		X		X	640	42.7
AH-64D Flight Dynamics	1	X	X	X	X	2368	157.9
AH-64D Propulsion	1	X	X	X	X	1600	106.7
AH-64D Physical Cues	1	X	X	X	X	1920	128.0
AH-64D TNE (see SSM Base)	1	X	X	X	X	0	0.0
Support Software	Note 10						
Overall	*2*						
Session Manager	2	X	X	Note 3	Note 11	5438	181.3
Operations and Logistics Support	3	X	X	X	X	5280	352.0
Aviation Mission Planner	2	X	X	Note 3	X	5800	193.3
After Action Review	2	X	X	Note 3	X	10000	333.3
ARWA LAN	2	X	X	Note 3	Note 11	790	26.3
DIS Network Manager	2	X	X	Note 3	Note 11	3871	129.0
ModSAF	Note 12						
				Total LOC		185887	8001.5
				Labor years			3.8

NOTES

X	Specific V&V activity required.	
1	Assumes Level 1 V&V intensity.	
	- Assumed LOC per hour to perform Verification.	30
	- Assumed LOC per hour to perform Validation.	30
2	2 labor months for overall VSM V&V.	
3	Only functional verification is required.	
4	Verified and validated by passing VSM acceptance test.	
5	Assumes higher rate LOC per hour.	240
6	Assumed higher rate LOC per hour.	240
7	2 labor months for overall FSM V&V.	
8	Validated by passing FSM acceptance test.	
9	2 labor months for overall SSM Base V&V.	
10	Support Software had previously been rated Level 3.	
11	Verified and validated by passing DIS device acceptance test.	
12	ModSAF will be V&V'd under a separate, leveraged DO.	

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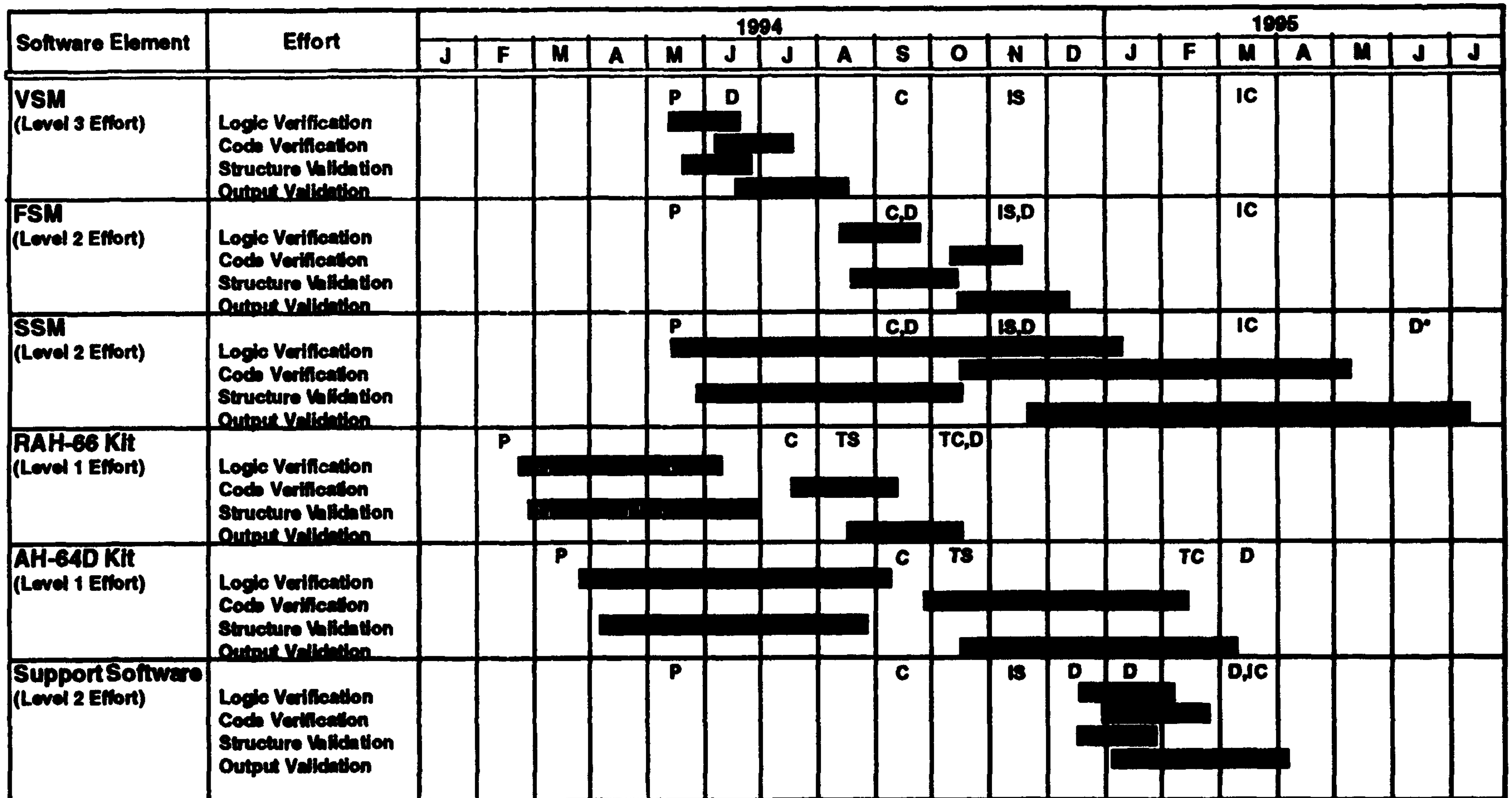
2.4 SCHEDULE

A top level summary schedule of V&V activities is shown in Figure 2.4-1. The basic timeline associated with the output validation process of individual segments is shown in this figure. The timeline associated with the integration of all simulator segments will require the iteration of output validation of each segment as the integration progresses.



KEY EVENTS

P - PDR Data Available
C - CDR Data Available
D - Software Delivery
D*- Environment Software Delivery
IS - Integration Start
IC - Integration Complete
TS - Start Kit Software Testing
TC - Complete Kit Software Testing

NOTES

- The length of the lines above represent the possible duration of each effort.
- The manpower available for each effort is reflected in the overall level of effort value associated with each subsystem.
- The V&V process will require iterative output validation as subsystems are integrated into the system.
- Testing of Kit subsystems will be performed by MDHC and BOEING prior to integration by LORAL.
- LORAL begins integration of subsystems in late November 1994 and completes I&T in March 1995.

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Figure 2.4-1 SCHEDULE OF V&V ACTIVITIES

2.5 Configuration Management

This section (2.5) was extracted from a document provided by Loral. This document is being updated and modified to meet the ARWA SS requirements. This excerpt was included to provide a general description of the CM plan that Loral proposes to adopt for the ARWA SS program.

Loral has established the Configuration Management (CM) practices and procedures to be followed in support of the Advanced Distributed Simulation Technology (ADST) contract by Loral Advanced Distributed Simulation (LADS). The plan describes the CM practices and procedures required for the concurrent, multi-site development and support of the ADST BDS-D (Battlefield Distributed Simulation-Development) programs. This plan addresses the Software Development Facility in Orlando, and subcontractors working on ADST Delivery Orders (DO's), Ft. Knox and Ft. Rucker.

A contractor managed, Configuration Control Board (CCB) will be established at the Loral ADST, Orlando facility, which will monitor, approve, and control changes to the common ADST product baseline. The centralized CCB will be responsible for adjudicating baseline changes proposed by the various development, operational, and integration functions. This plan describes the configuration change control procedures to be followed by the CCB and identifies the relationship of development and integration sites (i.e., Orlando, Ft. Knox, Boeing - Huntsville, MDHC - Mesa, and Ft. Rucker) and subcontractors working on ADST Delivery Orders (DOs).

Each Delivery Order (DO) organization will apply standard practices and processes to its design/development and integration activity. Systems Engineering will be responsible for the initiation, development, and coordination of all DO's on the ADST program. CM will work closely with software and systems engineering to assure consistency, and integrity of the initial submissions, procedural changes and traceability of software and hardware components. Systems Engineering, along with the Program Engineering Manager will be a liaison with the CCB and will coordinate with software engineering, integration and CM on software deliveries. In order to ensure consistency between sites and DO's, and adherence to the policy and procedures set forth in this plan, CM operations are coordinated with the BDS-D Manager, Site coordinators, and the Loral ADST Program Office-Orlando.

A key component of the plan will be the identification and establishment of the common ADST software baseline as a reusable system component as well as identifying site unique differences. The control mechanisms described in this plan serve as the foundation of a tailorable standard applied to all ADST BDS-D Delivery Order (DO) efforts in addition to ongoing baseline maintenance.

The LORAL CM system described in this plan is based upon DI-CMAN-80858 and MIL-STD-1456A as tailored to the ADST program. Although the ADST program is not a MIL-STD project, MIL-STD-1465A definitions and terminology are used throughout this document.

Table 2.5-1 shows the set of Software Support Operating Procedures being proposed to supplement the CM plan.

TABLE 2.5-1 SOFTWARE SUPPORT OPERATING PROCEDURES DOCUMENTS

SSOP NO.	TITLE
SSOP-0001	SSOP PURPOSE/PROCEDURE
SSOP-0002	CONFIGURATION CONTROL BOARD (CCB) CHARTER
SSOP-0003	PROBLEM REPORTING PROCEDURE
SSOP-0004	INTEGRATION AND TEST PROCEDURE (IN PROGRESS)
SSOP-0005	CODE CHECKOUT/ FILE TRANSFER PROTOCOL (FTP)
SSOP-0006	ADST LAB RULES AND PROCEDURES
SSOP-0007	CM TURNOVER PROCEDURE
SSOP-0008	REVISION CONTROL SYSTEM (RCS) HEADER COMMENT STANDARDS
SSOP-0009	DELIVERY ORDER RELEASE KITS
SSOP-0010	CM/SDF BUILD LOAD DISTRIBUTIONS
SSOP-0011A	REVISION CONTROL SYSTEM (RCS) Draft Update
SSOP-0012	VERSION MASTER SYSTEM
SSOP-0013	CHANGE CONTROL/BUILD PROCEDURE FIELD SUPPORT
SSOP-0014	SP/CR AUDIT TRAILS
SSOP-0015A	BDS-D DATA TRANSFER
SSOP-0016A	ADST DOCUMENT PREPARATION/RELEASE
SSOP-0017	ADST PROPRIETARY DATA PROCEDURES

3.0 V&V RESPONSIBILITIES

This section defines the agencies that have an active part in the V&V process along with their roles and responsibilities. Section 3.1 defines the membership and responsibilities of the V&V Steering Committee. Section 3.2 lists each participating party and the products which they are responsible for verifying. Section 3.3 lists each participating party and the products which they are responsible for validating. Section 3.4 lists the responsibilities of the accrediting agencies.

3.1 V&V STEERING COMMITTEE

Loral is the prime contractor responsible for the ADST ARWA delivery order. Loral has contracted with SPARTA for a V&V effort of the ARWA. Loral is responsible for management, coordination, and technical direction of the ARWA team. As a member of the ARWA Steering Committee, Loral has the following responsibilities:

a. Co-chair the ARWA V&V Steering Committee with STRICOM.

b. Coordinate the execution of the V&V process with STRICOM.

c. Designate Loral representation.

d. Ensure that the products of the development effort and the V&V process meet the requirements of the accrediting agency.

e. Provide the following data/effort:

   (1) Research and documentation of V&V based, existent software models for use by ARWA SS.

   (2) Methodology to be used (structured walk-through techniques), to determine if models and simulation will correctly perform the intended functions.

   (3) Results of source code inspection.

   (4) Data documentation.

   (5) Configuration control documentation.

   (6) Test reports.

   (7) Strawman V&V Plan

f. Manage and coordinate the efforts of the ADST ARWA DO team.

g. Provide additional assistance to the V&V Steering Committee as appropriate.

SPARTA is the subcontractor responsible for the V&V effort on the ARWA SS ADST delivery order managed by Loral. SPARTA is not an independent V&V (IV&V) agent. As part of the ARWA development team, SPARTA must ensure that the products of the development meet the V&V requirements of the accrediting agency. SPARTA's SOW defines the data which SPARTA must deliver. As a member of the ARWA Steering Committee, SPARTA must provide the following to the committee:

a. A plan for the coordination and integration of the Configuration Management and V&V Processes, to include:

  (1) Hardware/software requirements to support distributed development, V&V, and Configuration Management.

  (2) A schedule of software deliveries based on inputs from the software developers (Loral, Boeing, and MDHC).

b. An identification, definition, and format of the V&V products.

c. An identification of the data, models, and simulation, and processes used in V&V and a schedule of when those items will be available based on inputs from all available sources.

d. Proposed assignments of committee members to specific review or analysis tasks and a schedule of when those reviews or analyses must be completed. These may be provided on the scheduled meeting dates or at other times if appropriate.

The TSM Comanche role will be:

a. Provide operational input as required.

b. Coordinate with TEXCOM to identify AMSAA funding requirements in the FDT Outline Test Plans.

c. Participate in validations at the module integration level.

d. Conduct validations of system performance upon completed simulator.

The TSM Longbow role will be:

a. Provide operational input as required.

b. Coordinate with TEXCOM to identify AMSAA funding requirements in the FDT Outline Test Plans.

c. Participate in validations at the module integration level.

d. Conduct validations of system performance upon completed simulator.

AMSAA will chair the ARWA sub-committee on information sources and models.

3.2 VERIFICATION

Loral ADST - FSM, VSM, SSM Base, and Support Software
(Operations/Logistics, After Action Report, DIS I/F, Mission Planner, Session Manager, Network Manager, and Environment)

SPARTA - Ensure the verification of the following: VSM, FSM, FSM Base, FSM Comanche, FSM Longbow, SSM Base, Cockpit Kits, RAH-66 Comanche Kit, RAH-66 Flight Controls, RAH-66 Nav/Comm, RAH-66 Weapons, RAH-66 Sensors, RAH-66 ASE, RAH-66 Flight Dynamics, RAH-66 Propulsion, RAH-66 Physical Cues, RAH-66 TNE, AH-64D Longbow Kit, AH-64D Flight Controls, AH-64D Nav/Comm, AH-64D Weapons, AH-64D Sensors, AH-64D ASE, AH-64D Flight Dynamics, AH-64D Propulsion, AH-64D Physical Cues, AH-64D TNE; Support Software: Session Manager, Operations and Logistics Support, Aviation Mission Planner, After Action Review, ARWA LAN, and DIS Network Manager.

AMSAA - Models, documentation, leads to expert personnel

Boeing - RAH66 Software Kit
(Flight Controls, Nav/Comm, Weapons, Sensors, ASE, Flight Dynamics, Physical Cues, and TNE)

MDHC - AH64D Software Kit
(Flight Controls, Nav/Comm, Weapons, Sensors, ASE, Flight Dynamics, and Physical Cues)

Pulau - FSM Crewstation Base, RAH-66 Hardware Kit, AH-64D Hardware Kit

3.3 VALIDATION

STRICOM - Coordinate validation activities and approve validation agencies
- Review and approve validation reports from Loral and SPARTA
- TBD

Loral ADST - Coordinate validation activities among developers
- TBD

SPARTA - Ensure the validation of the following: VSM, FSM, FSM Base, FSM Comanche, FSM Longbow, SSM Base, Cockpit Kits, RAH-66

Comanche Kit, RAH-66 Flight Controls, RAH-66 Nav/Comm, RAH-66 Weapons, RAH-66 Sensors, RAH-66 ASE, RAH-66 Flight Dynamics, RAH-66 Propulsion, RAH-66 Physical Cues, RAH-66 TNE, AH-64D Longbow Kit, AH-64D Flight Controls, AH-64D Nav/Comm, AH-64D Weapons, AH-64D Sensors, AH-64D ASE, AH-64D Flight Dynamics, AH-64D Propulsion, AH-64D Physical Cues, AH-64D TNE; Support Software: Session Manager, Operations and Logistics Support, Aviation Mission Planner, After Action Review, ARWA LAN, and DIS Network Manager.

AMSAA	- Validated models
Boeing	- Documentation of any validated models they believe pertinent
MDHC	- Documentation of any validated models they believe pertinent

3.4 ACCREDITATION

STRICOM	- TBD
Loral ADST	- TBD
AMSAA	- TBD

4.0 INTENDED USE OF THE ARWA SIMULATOR

A detailed description of the defined purpose and expectation of the simulator will be provided (development, evaluation of and experimentation with tactics for "Move, Shoot and Communicate").

The model category and sub-category will be identified.

The problem that the simulator is intended to solve will be defined and specific questions that the simulator is expected to contribute toward answering will be included.

4.1 DEFINED PURPOSE AND EXPECTATION

4.1.1 Missions

Each of the ARWA devices shall be capable of performing the tasks identified in the following paragraphs as applicable to each configuration.

4.1.1.1 Flight Operations

Flight operations, tasks and procedures shall be simulated and performable in the ARWA devices to the level of fidelity defined herein.

4.1.1.1.1 Ground Operations

Ground operations shall include tactical resupply and rearming. Ground operations do not include engine start, engine run-up, engine and aircraft shutdown. Manual mission loading by keyboard entry or electronic media loading shall be supported. High fidelity taxi capabilities are not required.

4.1.1.1.2 Takeoff and Landing

Simulation of the transition from the ground environment to flight and from flight to the ground environment, including aerodynamic ground effects shall be provided.

4.1.1.1.3 Specific Flight Operations

The ARWA devices shall provide the capability to simulate low level, contour, nap of the earth, masking and unmasking, and hovering flight to the level of fidelity defined in paragraph 4.1.1.2.

4.1.1.2 Mission Specific Operations

The ARWA devices shall simulate the aircraft functions needed to move, shoot, communicate, perform surveillance, attack, defend, rearm, and resupply, to the level of fidelity defined below:

a. Reconfiguration, which includes cockpit changeout and system reintialization to a predetermined configuration, but excludes parameter modification, shall not require more than sixty (60) minutes to accomplish.

b. Interoperability with other simulators in the network shall be defined by the Distributed Interactive Simulation (DIS) protocols as extended by BDS-D.

c. Malfunctions shall be limited to those that are a direct consequence of simulated battle damage. There shall be no discretely selectable stochastic or operator insertable malfunctions. The malfunctions defined in Appendix B of the System/Segment Specification for the Advanced Rotary Wing Aircraft Simulator System Volume I shall be implemented as defined in the TSA/SFA.

d. The System shall be designed to operate at the "system high" level by the document which defines facility security policies. The capability to declassify the System through media removal and classified data erase programs shall be provided. Classified data erase programs are not required for the Visual module item and image memory.

e. Pre-mission access to critical system parameters (e.g., weapon ranges, sensor ranges, etc.) shall be provided to allow rapid modification to support simulator experiments. Parameter modification shall not require recompilation of source software to implement changes.

f. Simulation capabilities to move, shoot, communicate, rearm, and be resupplied in a simulated war fighting environment shall be provided. Simulation for aspects involving mission pre-flight, start-up, run-up, shutdown, and post-flight procedures is not required.

g. Simulation to support equipment pre-flight, post flight, checkout, and adjustment/calibration procedures is not required.

h. Simulation of equipment operational characteristics such as power/circuit breaker status, warm-up times, overheat/reset conditions, built-in-test, delays, and failures induced by incorrect crew member procedures is not required. Equipment power-on status shall be defined during pre-mission initialization.

i. Simulation of equipment interference effects caused by other onboard aircraft systems is not required.

j. The System shall be capable of reporting its hardware and software configuration to support analysis and documentation of experiments and to ensure integrity of the hardware for security reasons.

4.2 Model Hierarchy

The ARWA SS is composed of the following major components and sub components.

- VSM
- FSM
  - FSM Base
  - FSM Comanche
  - FSM Longbow
- SSM Base
- Cockpit Kits
  - RAH-66 Comanche Kit
    - RAH-66 Flight Controls
    - RAH-66 Nav/Comm
    - RAH-66 Weapons
    - RAH-66 Sensors
    - RAH-66 ASE
    - RAH-66 Flight Dynamics
    - RAH-66 Propulsion
    - RAH-66 Physical Cues
    - RAH-66 TNE
  - AH-64D Longbow Kit
    - AH-64D Flight Controls
    - AH-64D Nav/Comm
    - AH-64D Weapons
    - AH-64D Sensors
    - AH-64D ASE
    - AH-64D Flight Dynamics
    - AH-64D Propulsion
    - AH-64D Physical Cues
    - AH-64D TNE
- Support Software
  - Session Manager
  - Operations and Logistics Support
  - Aviation Mission Planner
  - After Action Review
  - ARWA LAN
  - DIS Network Manager
  - ModSAF

4.3 USES OF THE SIMULATION

The ARWA SS is to be used to assist the Army in the rapid exploration of current and emerging tactics, doctrine and combat development issues. It will be able to perform:

- single aircraft exercises,
- team operations, and
- armed recon and attack helicopter coordination activities.

These will be performed in real-time by reconfigurable RAH-66 and AH-64D devices, engaged in simulated warfighting exercises, operating on the Battlefield Distributed Simulation Development (BDS-D) network. The simulated aircraft will thus be able to realistically interact with each other, with the terrain and cultural features, and with external simulated forces in order to simulate a tactical environment. This environment will permit the aircraft to perform realistic missions and flight operations, and give them the ability to employ all nav/com equipment, sensors, aircraft survivability equipment, and weapons with which they are equipped. All significant events that occur during the conduct of an exercise will be logged for real-time and post-mission analysis.

5.0 INFORMATION SOURCES

This section identifies information sources relative to the ARWA V&V activity:

Identification of the ARWA Simulator documentation. Requirements documents, System Specifications, METL, TSA, SFA study documentation, ...

Identification of key personnel who participated in the development of the simulator. Developers, proponents, ...

Identification of the SME's or other personnel who will define the "real world" relative to the ARWA simulator.

Identification of the "real world" data points for use as comparative data.

5.1 LORAL

5.2 BOEING

5.3 MDHC

5.4 STRICOM

5.5 COMANCHE TSM

5.6 LONGBOW TSM

5.7 AMSAA

5.8 SPARTA DEFINED SOURCES

5.8.1 RAH-66 RELATED INFORMATION

SPARTA will assemble and review the following documents prior to performing verification and validation activities on the RAH-66 simulator:

1. System/Segment Specification for the RAH-66 Simulator System Module (Sxxx-xxxxx)
2. Software Requirements Specification For The Flight Dynamics Segment Of The ARWA RAH-66 Simulator System Module (S567-XXXXX)
3. Software Requirements Specification For The Flight Controls Segment Of The ARWA RAH-66 Simulator System Module (S567-XXXXX)
4. Segment Design Document For The RAH-66 Flight Control System (2000-741-500)
5. Software Requirements Specification For The Primary Flight Control Processor Of The RAH-66 Comanche Flight Control System (2000-744-001)

6. Primary Flight Control Processor Software Vendor Drawings (2000-744-001)
7. Software Requirements Specification For The Automatic Flight Control Processor Of The RAH-66 Comanche Flight Control System (2000-744-002)
8. Automatic Flight Control Processor Software Vendor Drawings (2000-744-002)
9. Software Requirements Specification For The Flight Director Of The RAH-66 Comanche Flight Control System (2000-744-500)
10. Software Requirements Specification For The Propulsion Segment Of The ARWA RAH-66 Simulator System Module (S567-XXXXX)
11. Software Requirements Specification For The Object Library (OL) Of The RAH-66 Comanche Flight Control System (2000-744-503)
12. Boeing-Helicopter BH-SIM Flight Controls Code, Drawings and Documentation
13. Pilot-Vehicle Interface Mechanization Specification RAH-66 Comanche 2000-730-002B)
14. Block 2 Pilot Vehicle Interface Mechanization Specification (2000-730-002B)
15. Air Vehicle Preliminary Design Report (2000-310-003)
16. APPENDIX A RAH-66 Comanche Switches, Controls and Displays, Selective Fidelity Charts
17. Configuration Item Development Specification For The Comanche Cyclic And Collective Control Grips (2000-745-004)
18. T800 Engine Data from Maj. Ochsner
19. Advanced Distributed Simulation Technology Rotary Wing Aircraft Step 1 Final Report (D567-30991)
20. Advanced Rotary Wing Aircraft RAH-66 Task and Skills Analysis And Selective Fidelity Analysis Block 2 Revision 1.0 (L-E-91-129-10-93)
21. SH-60F (CV-HELO) Listings (HQ4107-1)
22. SH-60F (CV-HELO) Program Design Specification (HQ4107-2)
23. SH-60F (CV-HELO) Math Models (HQ4107-3)
24. RAH-66 Weight and Balance Status Report No. 9 (2000-114-012)
25. Boeing-Helicopter BH-SIM Flight Code, Drawings and Documentation

5.8.2 AH-64D RELATED INFORMATION

The following documents are not currently available for the AH-64D. However, these documents or ones which contain similar information should be available after the associated development phase.

1. System/Segment Specification for the AH-64D Simulator
2. Software Requirements Specification For The Flight Dynamics Segment Of The AH-64D Simulator

3. **Software Requirements Specification For The Flight Controls Segment Of The AH-64D Simulator**
4. **Segment Design Document For The AH-64D Simulator Flight Control System**
5. **Software Requirements Specification For The Primary Flight Control Processor Of The AH-64D Simulator**
6. **Software Requirements Specification For The Flight Director Of The AH-64D Simulator**
7. **Software Requirements Specification For The Object Library (OL) Of The AH-64D Simulator**
8. **Software Requirements Specification For The Propulsion Segment Of The AH-64D Simulator**

The following documents have previously been identified as sources of information on the AH-64D.

9. ARMY Airspace Command and Control in a Combat Zone, Y, 10/07/87, FM 100-103, SIMNET
10. Field Manual - Air Assault Operations, ?, 03/16/87, FM 90-4, SIMNET
11. Field Manual - Air Combat Operations Approved Final Draft, Y, 06/01/89, FM 1-107, SIMNET
12. Field Manual - Aircraft Battlefield Countermeasures and Survivability, 06/01/89, FM 1-101, SIMNET
13. Field Manual - Attack Helicopter Battalion, Y, 07/14/86, FM 1-112, SIMNET
14. US Army Air Defense Artillery Employment, Change 1Y, 08/28/84, FM 44-1, SIMNET
15. APACHE Pictorial Reference Book, Y, 06/01/85, SIMNET
16. Operator's Manual for Army AH-64A Helicopter, Change 18, 08/29/90, TM-55-1520-238-10, IEI
17. US Army Aviation Center AirNet Standing Operating Procedure (SOP), ?, SIMNET
18. SIMNET Ethernet Performance, Y, SIMNET
19. Instructor Guide, AH-64 Cockpit Weapons Emergency Procedure Trainer (CWEPT) (Copilot/Gunner), Y, 02/01/89, 15-6454-7.5, B. Crabtree
20. Instructor Guide - AH-64 SWEPT (Pilot), Y, 03/01/89, 156452-7.5, B. Crabtree
21. Mission Training Plan for the Attack Helicopter Company, Y, 05/18/89, ARTEP-1-187-30-MTP, SIMNET
22. Lesson Plan - AH-64A Avionics and Doppler, Y, 01/01/88, 33-0295-2, SIMNET
23. Lesson Plan - AH-64H Operating Limits/Flight Characteristics, 01/01/90, 15-6427-3, SIMNET
24. Student Handout - AH-64A Operating Limits/Flight Characteristics, 03/01/89, 15-6427-3, SIMNET

25. Lesson Plan - AH-64 Utility System, Y, 01/01/90, 15-6428-2, SIMNET
26. Student Handout - AH-64 Utility System, Y, 10/01/87, 15/32/33-6428-2, SIMNET
27. Lesson Plan - AH-64A Flight Controls, Y, 01/01/90, 15-6429-2, SIMNET
28. Student Handout - AH-54A Flight Controls, Y, 07/01/87, 15/32/33 6429-2, SIMNET
29. Lesson Plan - AH-64A Digital Automatic Stabilization Equipment (DASE), 02/01/88, 15/33-6430-2.5, SIMNET
30. Student Handout - AH-64A Digital Automatic Stabilization Equipment (DASE), Y, 02/01/88, 15/33-6430-2.5, SIMNET
31. Lesson Plan - AH-64A Multiplex System, Y, 01/01/88, 15/33-6431-1, SIMNET
32. Student Handout - Multiplex System (MUX), 01/01/86, 15/32/33-6431-1, SIMNET
33. Lesson Plan - AH-64A Fault Detection/Location System (FD/LS), 01/01/88, 15/33-6432-2, SIMNET
34. Student Handout - AH-64A Fault Detection/Location System (FD/LS), 01/01/88, 15/33-6432-2, SIMNET
35. Lesson Plan - AH-64A Avionics, Y, 01/01/89, 15-6433-3, SIMNET
36. Student Handout - AH-64A Avionics, Y, 01/01/89, 15-6433-3, SIMNET
37. Lesson Plan - AH-64A Area Weapon System (AWS), 04/01/88, 15-6440-2, SIMNET
38. Student Handout - AH-64A Area Weapon System (AWS), 04/01/88, 15-6440-2, SIMNET
39. Lesson Plan - AH-64A Aerial Rocket Control System (ARCS), 03/01/88, 15-6442-2.5, SIMNET
40. Student Handout - AH-64A Aerial Rocket Control System (ARCS), 03/01/88, 15-6442-2.5, SIMNET
41. Lesson Plan - Point Target Weapon System, Y, 09/01/89, 15-6443-6, SIMNET
42. Student Handout - Point Target Weapon System, Y, 05/01/88, 15-6443-6, SIMNET
43. Lesson Plan - Introduction to the AH-64A, Y, 07/01/89, 15-6415-1, SIMNET
44. Student Handout - Introduction to the AH-64A, Y, 01/01/88, 15/33-6415-1, SIMNET
45. Lesson Plan - AH-64 Airframe and Survivability, Y, 06/01/89, 15-6416-2, SIMNET
46. Student Handout - AH-64 Airframe and Survivability, Y, 03/01/88, 15-6416-2, SIMNET
47. Lesson Plan - AH-64 Caution and Warning System, Y, 08/01/89, 15-6417-1, SIMNET
48. Student Handout - AN/ASN Doppler Navigation Set (DNS), Y, 06/01/89, 15/33-0311-4, SIMNET
49. Student Handout - FLIR Imagery Interpretation, Y, 03/01/88, 15-6405-1, SIMNET

50. Student Handout - Aircraft Survivability Equipment, Y, 08/01/88, 3K/4A/4G/4H/4L/15/31/33-1888-3, SIMNET
51. Student Handout - Infrared (IR) Theory and Modular Forward Looking Infrared (FLIR) Components, Y, 03/01/88, 15-6462-2, SIMNET
52. Student Handout - AH-64 Pilot Symbology, Y, 12/01/88, 15-6464-3, SIMNET
53. Aircrew Training Manual - Attack Helicopter, AH-64, Y, 05/31/86, FC 1-214, B. Crabtree
54. Program of Instruction - AH-64 Aviator Qualification Course, Y, 01/01/88, 2C-SUI1L/2C-152F, B. Crabtree

5.8.3 SPARTA'S ARWA LIBRARY

SPARTA currently has assembled and will utilize the following documents in performing verification and validation activities on the ARWA Simulator System:

1. SPARTA Proposal LRL02B, Universal Threat System for Simulators
2. System/Segment Specification for Generic Modular Simulator Vols 8-12, 14 and Appendix A
3. SMART Briefing
4. Modular Simulator Executive Report, 8/25/93,Boeing (D495-10441-1)
5. ARWA Briefing - LADS Orlando Operation, 10/24/93, LORAL
6 The Use of Pilot Rating in the Evaluation of Aircraft Handling Qualities, 4/1/69, Ames Research
7. Prototype AH-64 Simulator (Draft)
8. System/Segment Specification for Generic Modular Simulator Vols. I thru VII, 2/4/93, Boeing (S495-10400C)
9. System/Segment Specification for Rotary Wing Aircraft Simulator System (Draft), 10/4/93, Boeing
10. Anti-Armor Advanced Technology Demonstration (A2ATD) D.O., 9/27/93, LORAL
11. Executive Summary of AMSAA Trip Report, 4/2/93, LOARL
12. The ARWA V&V Steering Committee Meeting 1, 11/1/93, SPARTA
13. LORAL ARWA V&V Program Management Review - Briefing, 9/23/93, SPARTA
14. ARWA Program Management Review No. 1 September 22-23,1993, LORAL
15. Close Combat Tactical Trainer Data Structures, Algorithms, and Generic System Mapping, 5/1/93
16. RAH-66 Task and Skills Analysis and Selective Fidelity Analysis, 2/1/92, LORAL
17. ARWA V&V RFP/SOW Volume 1, LORAL
18. ARWA PMR #1 Minutes 9/22/93
19. Distributed Interactive Simulation Common Database Standard
20. Battlefield Distributed Simulator - Developmental (BDS-D Model V&V & Accreditation Plan

21. Response to Action Item #4 form V&V steering Committee Meeting #1
22. Preliminary Design Review (PDR) Presentation Package for Subcontractor Strawman V&V Plan (Phase 1)
23. Model List for ARWA, 11/10/93, LORAL
24. MDHC ARWA Schedule (Revision 1), 11/1/93
25. Boeing Simulator System Module Schedule, 6/3/93, Boeing
26. Anti-Armor Advanced Technology Demonstration (A2ATD)
27. V&V Technical Volume for Experiment 1 Anti-Armor Advanced Technology Demonstration (A2ATD)
28. The Verification and Validation Plan Status, 12/03/93
29. V&V Steering Committee Meeting 2, 12/02/93
30. RWA Engineering Design Review-1 & Design Criteria Conference, 2/27/92
31. Advanced Development Model Air Tactics, Tactical Environment Modeling, Data Requirements, and Resources
32. Concise Guide to Issue/ Discrepancy Analysis and Tracking
33. S/W Requirement Specification - Aircraft Survivability Equipment Segment of the ARWA RAH-66 Simulator System Module, 11/24/93, Boeing (S567-XXXXX)
34. S/W Requirement Specification - Control Segment of the ARWA RAH-66 Simulator System Module, 11/24/93, Boeing (S567-XXXXX)
35. S/W Requirement Specification - Environment Segment of the ARWA RAH-66 Simulator System Module, 11/24/93, Boeing (S567-XXXXX)
36. S/W Requirement Specification - Flight Dynamics Segment of the ARWA RAH-66 Simulator System Module, 11/24/93, Boeing (S567-XXXXX)
37. S/W Requirement Specification - Navigation/Communication Segment of the ARWA RAH-66 Simulator System Module, 11/24/93, Boeing (S567-XXXXX)
38. S/W Requirement Specification - Physical Cues Segment of the ARWA RAH-66 Simulator System Module, 11/24/93, Boeing (S567-XXXXX)
39. S/W Requirement Specification - Propulsion Segment of the ARWA RAH-66 Simulator System Module, 11/24/93, Boeing (S567-XXXXX)
40. S/W Requirement Specification - Sensors Segment of the ARWA RAH-66 Simulator System Module, 11/24/93, Boeing (S567-XXXXX)
41. S/W Requirement Specification - Weapons Segment of the ARWA RAH-66 Simulator System Module, 11/24/93, Boeing (S567-XXXXX)
42. S/W Requirement Specification - Flight Controls Segment of the ARWA RAH-66 Simulator System Module, 11/24/93, Boeing (S567-XXXXX)
43. Advanced Distributed Simulation Technology Rotary Wing Aircraft, 11/24/93, Boeing (D567-30991)
44. Army Model and Simulation Management Program, 6/10/92, HQ Dept. of the Army

5.8.4 MODEL DOCUMENTATION LIBRARY

SPARTA currently has assembled and will utilize the following model documentation in performing verification and validation activities on the ARWA Simulator System:

1. Air Defense Air-to-Ground Engagement (ADAGE) Simulation, Volume II, The Incursion Model, May 1978, AMSAA Technical Report Number 227, U.S. Army Material System Analysis Activity
2. Low Energy Laser Weapon Simulation (LELAWS) Volume I - Analyst's Manual, 27 March 1987, SPARTA Inc.
3. Low Energy Laser Weapon Simulation (LELAWS) Volume II - User's Manual, 30 December 1986, SPARTA Inc.
4. C2NVED Thermal Imaging Systems Performance Module FLIR90, 18 May 1990, U.S. Army CECOM Center for Night Vision & Electro-optics, FT. Belvoir, VA
5. C2NVED Thermal Imaging Systems Performance Module, 18 May 1990, U.S. Army CECOM Center for Night Vision & Electro-optics, FT. Belvoir, VA

6.0 VERIFICATION AGENDA

The logic and code verification procedures, products, and data requirements described below represent the complete set of activities that would be performed for V&V Intensity Level 1. The specific logic and code verification activities to be performed for each ARWA SS component are defined in Section 6.3.

The following is an outline of the verification activities:

- Logic verification
  - Library development
  - Documentation Review
  - Design Walk-Throughs
  - Flow Diagram Reviews
  - Algorithm Checks
  - Comparison of Pseudo-code to the Design Specifications
  - Logic Representation

- Code verification
  - Code Walk-Throughs
  - Peer Review
  - Units Check
  - Logic Representation
  - Sensitivity Analysis
  - Statistical Tests for Stochastic Models

6.1 LOGIC VERIFICATION METHODOLOGY

The following sections describe the activities required to verify the logic of the segment design. The purpose of these activities is to ensure that the design correctly meets the requirements. When possible the logic should be verified prior to the start of coding.

6.1.1 Library Development

The ARWA V&V team will identify and assemble all key documentation required to perform the verification and validation tasks. These will include ARWA SS specification and design documents, as well as reference "truth" documents that will primarily be used in the validation phase.

6.1.2 Documentation Review

The verification team will make a thorough review of all design and specification documents to gain a clear understanding of what the requirements are for each software segment and functional elements of it. These comprise the basic criteria upon which the verification process is based and will be well documented in the verification and validation (V&V) report.

The documents to be reviewed include, but are not limited to, the System/Segment Specification (SSS), the Software Requirements Specification (SRS), and the Interface Requirements Specification (IRS).

The SSS will be compared against the ARWA SS technical requirements document. A traceability matrix will be constructed to map requirements into the lower level documents. Any discrepancies will be noted in the discrepancy and problem tracking data base maintained by the CCB. The SRS and IRS will be compared to the SSS to assure that all specifications have been addressed and that no software or interface requirement exits which cannot be matched to a corresponding specification. This traceability information will also be input to the V&V documentation to support further traceability efforts. Any discrepancies will be noted in the discrepancy and problem tracking data base maintained by the CCB.

6.1.2.1 Pre-PDR Phase

Data Sources

Table 6.1.2.1-1 describes the data sources that can be used during the Pre-PDR phase.

Title	Description	Format Guide	Source	Associated Procedure
System/ Segment Specification	Functional allocation of technical requirements to various system configuration items	TBD (DI-CMAN-80008A)	Gov't - Functional Baseline	1,2
Software Requirements Specification	Specifies the software technical and qualification requirements for a module	TBD (DI-MCCR-80025A)	Draft-Developer; Final	1,2
Interface Requirements Specification	Specifies the requirements for interfaces among modules or other configuration or critical items	TBD (DI-MCCR-80026A)	Draft-Developer; Final- Gov't Allocated Baseline	1,2
Developers Contract SOW, Format Guide and tailored DIDs	Document Format and Content Requirements	N/A	Gov't	1,2

Table 6.1.2.1-1 Pre-PDR Phase Verification Data Sources

Procedures

The following paragraphs describe the procedures that can be used during the Pre-PDR phase.

1. Review Software and Interface Requirements Specifications against the Systems Segment Specification to assure that all specifications have been addressed and that no software or interface requirement exists which can not be matched to a corresponding specification. Enter this traceability information in the V&V documentation to support further traceability efforts at the software design document level. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Produce V&V Plan identifying:

   - Higher level requirements which are not addressed,
   - Software and Interface requirements which are not traceable to a higher-level specification,
   - Format and content discrepancies,
   - Requirements which are untestable and/or unambiguous.

2. Support Reviews and Audits by:

   - Providing briefing material containing summary status information for each critical module. Summary information will include software size estimates, schedule (planned versus actual), and action items to be addressed during the meeting,
   - Participating in the review as directed by the Prime.

Products

Table 6.1.2.1-2 defines the V&V products of the Pre-PDR phase.

Title	Description	Format Guide	Frequency
V&V Plan	Report on the completeness of the Systems/Segment Specification (from the software perspective)	TBD	Initial one -time, update as required by ECPs affecting the SSS
V&V Plan	Report on the completeness of the Software Requirements Specification (one per Module)	TBD	Once per Module
V&V Plan	Report on the completeness of the interface requirements specification (one per Module)	TBD	Once per Module

Table 6.1.2.1-2 Pre-PDR Phase Verification Products

The V&V Plan will contain the following results of the Pre-PDR activities:

- Requirements that are not addressed
- Requirements which can not be matched to a higher level specification
- Requirements in the SSS not previously identified in the technical requirements document or other early requirements documents
- Higher level requirements which are not addressed
- Software and Interface requirements which are not traceable to a higher-level specification

- Requirements which are untestable and/or ambiguous
- Format and content discrepancies

6.1.2.2 PDR Through CDR Phase

Data Sources

Table 6.1.2.2-1 describes the data sources that can be used from PDR through the CDR Phase.

Title	Description	Format Guide	Source	Associated Procedure
Software Design Documents (Preliminary)	Specifies the preliminary design of the CSCI.	TBD (DI-MCCR-80012A)	Developer	1,3
Interface Design Documents (Preliminary)	Specifies the preliminary design of one or more interfaces between CSCI(s).	TBD (DI-MCCR-80027A)	Developer	1,3
Software Design Documents (Detailed)	Specifies the detailed design of the CSCI to the CSU level.	TBD (DI-MCCR-80012A)	Developer	1,3
Interface Design Documents (Detailed)	Specifies the detailed design of one or more interfaces between CSCI(s) or other configuration or critical items.	TBD (DI-MCCR-80027A)	Developer	1,3
Software Test Plan	Defines the software test environment resources required, the schedule of test activities, and the individual test to be performed.	TBD (DI-MCCR-80014A)	Developer,	2,3
Developers Contract SOW, Format Guide and tailored DIDs	Document Format and Content Requirements	N/A	Gov't	1,2,3

Table 6.1.2.2-1 PDR Through CDR Phase Verification Data Sources

Procedures

The following paragraphs describe the procedures that can be used from PDR through the CDR Phase.

1. Review Detailed Software and Interface Design Documents against the Preliminary Software and Interface Design Documents as well as the Software and Interface Requirements Specification. The goal as before is to assure that all requirements

have been addressed and that no software or interface design feature exists which can not be matched to a corresponding requirement. Enter this traceability information in the V&V documentation to support further traceability efforts at the coding and unit test level. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

- Requirements which are not addressed,
- Software and Interface design features which do not support a higher-level requirement,
- Format and content discrepancies.

2. Review Software Test Plan against the Software and Interface Requirements Specification. The software Test Plan defines the formal qualification tests for the CSCI, the software test environment resources required, the schedule of activities, and the individual test to be performed. The goal of this review is on the identification of test which will provide objective evidence that the CSCI meets its requirements. Enter this traceability information in the V&V documentation to support further traceability activities at the coding and unit test level. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

    - Requirements for which no test is identified,
    - Tests identified, but for which a requirement cannot be identified,
    - Level and type of testing to be performed to satisfy each requirement,
    - Format and content discrepancies.

3. Support Reviews and Audits by :

    - Providing briefing books containing summary status information for each critical CSCI. Summary information will include software size estimates, schedule (planned versus actual), and action items to be addressed during the meeting,
    - Participating in the review as directed by the Prime.

Products

Table 6.1.2.2-2 defines the V&V products from PDR through the CDR Phase.

Title	Description	Format Guide	Frequency
V&V Plan	Report on the completeness of the Preliminary Software Design Documents (one per module)	TBD	Once per module
V&V Plan	Briefing materials reflecting the status of each modules	TBD	Once per module

Table 6.1.2.2-2 PDR Through CDR Phase Verification Products

The V&V Plan will contain the following results from PDR through the CDR Phase:

- Preceding requirements (higher level) which are not addressed
- Preliminary software design and Interface design features which do not support a higher-level requirement
- Requirements which are not addressed
- Software and Interface design features which do not support a higher-level requirement
- Requirements for which no test is identified
- Tests identified, but for which a requirement cannot be identified
- Level and type of testing to be performed to satisfy each requirement
- Format and content discrepancies

6.1.2.3 Post CDR Phase

Data Sources

Table 6.1.2.3-1 describes the data sources that can be used during the Post-CDR Phase.

Title	Description	Format Guide	Source	Associated Procedure
Software Requirements Specification	Specifies the engineering and qualification requirements of a CSCI.	TBD (DI-MCCR-800-25A)	Developer	1,2,4,6
Interface Requirements Specification	Specifies the requirements for one or more interfaces between one or more CSCIs.	TBD (DI-MCCR-800-26A)	Developer	1,2,4,6
Software Design Documents (Detailed)	Specifies the detailed design of the CSCI to the CSU level.	TBD (DI-MCCR-80012A)	Developer	1,2,4,6
Interface Design Documents (Detailed)	Specifies the detailed design of one or more interfaces between CSCI(s)	TBD (DI-MCCR-80027A)	Developer	1,2,4,6
Source Code and Software Development Files (SDF)	From the Developmental Configuration, these represent the implementation of the design (the code) and the rationale supporting developer implementation decisions (the SDF)	TBD (Data Accession List)	Developer	2, 6
Software Test Plan	Defines the software test environment resources required, the schedule of activities, and the individual test to be performed.	TBD (DI-MCCR-80014A)	Developer,	3,5,6
Software Test Descriptions	Defines the test cases and procedures needed to perform formal qualification testing of a CSCI in accordance with the STP.	TBD)DI-MCCR-80015A)	Developer	3,5,6
Software Test Reports	Serves as a record of the formal qualification testing performed on a CSCI.	TBD (DI-MCCR-80017A)	Developer, Tester, Gov't	5,6
Developers Contract SOW, Format Guide and tailored DIDs	Document Format and Content Requirements	N/A	Gov't	1,2,3,4,5, 6

Table 6.1.2.3-1 Post-CDR Phase Verification Data Sources

Procedures

The following paragraphs describe the procedures that can be used during the Post-CDR Phase.

1. Review Detailed Software and Interface Design Documents during Coding, CSU Testing, CSC Integration, and Testing phases. This review compares the SDD and IDD products, while they are evolving in the contractor controlled Developmental Configuration, against the Software and Interface Requirements Specification to assure that all requirements continue to be addressed and that no software or interface design feature exists which can not be matched to a corresponding requirement. Enter this traceability information in the V&V documentation to support further traceability efforts as these SDD and IDD are updated. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

   - Requirements which are not addressed by design,
   - Software and Interface design features which do not support a higher-level requirement,
   - Format and content discrepancies based on the contractor specified format.

2. Review Source Code against the Detailed Software and Interface Design Documents as well as the Software and Interface Requirements Specification during Coding, CSU Testing, CSC Integration, and Testing phases. The goal as before is to assure that all requirements have been addressed and that no software or interface design feature is implemented in the code which can not be matched to a corresponding requirement. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

   - Requirements which are not addressed by code,
   - Software and Interface code features which do not support a requirement, or trace directly to design,
   - Non-adherence to the contractor's software standards and procedures format and content requirements.

3. Review Software Test Descriptions against the Software and Interface Requirements Specification and against the Software Test Plan. The software test descriptions begin by defining test cases prior to CDR and continue to be further refined by defining the test procedures. The goal of this review is similar to the preceding reviews, however we are focusing on the identification of the specific test cases and detailed procedures which will provide complete and objective evidence that the CSCI meets its requirements. Enter this traceability information in the V&V documentation to support further traceability activities. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

   - Requirements for which no test is identified,
   - Tests identified, but for which a requirement cannot be identified,
   - Format and content discrepancies.

4. Review Detailed Software and Interface Design Documents. This review compares the SDD and IDD products against the Software and Interface Requirements Specification to assure that all requirements have been addressed and that no

software or interface design feature exists which can not be matched to a corresponding requirement. Enter this traceability information in the V&V documentation. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

- Specifications which are not addressed,
- Software and Interface design features which do not support a higher-level requirement,
- Format and content discrepancies.

5. Review Software Test Reports against the Software and Interface Requirements Specification and against the Software Test Plan and Software Test Descriptions. The STR is reviewed for test completeness, insuring that all planned tests and procedures are documented with results. The goal of this review is to determine that all tests were exercised or explanations are present and that the results provided sufficient objective evidence that the CSCI meets its requirements. Enter this traceability information in the V&V documentation. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

   - Requirements for which no test is reported,
   - Tests identified, but for which a requirement cannot be identified,
   - Test results which do not support the objectives of the STP and STDs,
   - Tests which did not meet satisfactory completion, or achieve conditions defined in the STD under which the test result is inconclusive,
   - Format and content discrepancies.

6. Support Reviews and Audits by :

   - Providing briefing books containing summary status information for each critical CSCI. Summary information will include software size estimates, schedule (planned versus actual), and action items to be addressed during the meeting,
   - Participating in the review as directed by the Prime.

Products

Table 6.1.2.3-2 defines the V&V products from the Post-CDR Phase.

Title	Description	Format Guide	Frequency
V&V Plan	Report on the completeness of the Preliminary Software Design Documents (one per module)	TBD	Once per module
TBD			
V&V Plan	Briefing materials reflecting the status of each modules	TBD	Once per module

Table 6.1.2.3-2 Post-CDR Phase Verification Products

The V&V Plan will contain the following results from the Post-CDR Phase:

- Requirements which are not addressed by design
- Software and Interface design features which do not support a higher-level requirement
- Format and content discrepancies based on the contractor specified format contained in the Software Development Plan for items in the Developmental Configuration
- Requirements which are not addressed by code
- Software and Interface code features which do not support a requirement, or trace directly to design
- Non-adherence to the contractor's software standards and procedures format and content requirements
- Requirements for which no test is identified
- Tests identified, but for which a requirement that cannot be identified
- Specifications which are not addressed
- Software and Interface design features which do not support a higher-level requirement
- Tests identified, but for which a requirement cannot be identified
- Format and content discrepancies

6.1.2.4 Code and Unit Test

The following documentation should be provided during the coding and unit test phase:

- Test results which do not support the objectives of the STP and STDs
- Tests which did not meet satisfactory completion, or achieve conditions defined in the STD under which the test result is inconclusive
- Identify system/software requirements not clearly addressed including recovery from failure and alternatives
- Requirements for which no test is reported
- Format and content discrepancies

6.1.3 Design Walk-Throughs

The ARWA V&V team will conduct design walk-throughs in each functional area to check that the design will fulfill the specified requirements. These designs will be presented by the functional area designers and will allow the V&V team, including user community personnel, to establish that the designs are complete and balanced and meet the requirements of the user community. They will also give members of the V&V team an opportunity to better understand the designs and gain insight as to why certain design approaches were implemented.

The design will first be analyzed to see that it incorporates all of the functionality specified for that system. If all specified functionality seems to have been incorporated, then we can conclude that the code may work. If anything has been omitted or incorrectly

implemented, then we can conclude that the code will not work. It is critical that all logic statements be thoroughly checked, for, if errors are not found here, snags can result that, if encountered at a later stage of development, can be difficult to debug. For example, a SHOOT cue may only be obtained if the weapon is selected and armed, the seeker has locked on, the weapon is in range, and the target is within angular constraints. Thus, the design can be readily checked to see that all of these logic statements are present.

The designs will not only consider each functional element for such factors as algorithms and logic, but also for the relationship between them, to check that the interfaces have been properly defined. The areas addressed and the results of the reviews will be documented—in particular, the areas where deficiencies are found.

The specific documents to be reviewed are the preliminary and final Software Design and Interface Design Documents. These documents will be compared to the allocated baseline to assure that all requirements have been addressed and that no software or interface design requirement exists which can not be matched to a corresponding higher level requirement. Any discrepancies are entered into the discrepancy and problem tracking data base maintained by the CCB. The goal of reviewing these documents is to assure that all requirements have been addressed and that no software or interface design feature exists which can not be matched to a corresponding requirement. Additional data may be obtained from the Software Test Plan and the developers contract SOW.

6.1.4 Flow Diagram Reviews

The ARWA V&V team will review the flow charts, top-down structure diagrams, data flow charts, and related documentation in each functional area in conjunction with the design walk-throughs. Some of these data will actually be used in the design walk-throughs to present the material, while other data will be reviewed to supplement the information gained from the design walk-throughs.

6.1.5 Algorithm Checks

The ARWA V&V team will evaluate the level of fidelity of all key equations and algorithms in each functional area. The fidelity and mechanization will be evaluated against "accepted" approaches as defined in reference documentation that the V&V team will assemble in the library development task. The results of this activity will be documented to note which equations and algorithms were reviewed and the results of those reviews. The team will verify that the level of fidelity is sufficiently high to allow air crews to properly perform their R&D, tactics development, and evaluation activities in the ARWA SS.

6.1.6 Comparison of Pseudo-code to the Design Specifications

After the pseudo-code has been written for each software segment, the V&V team will compare it with the design requirements to see that all requirements have been

implemented. This is a critical task because it is probable that the person who created the design code will not code it up. The ARWA V&V team will document the results of this review, with special note being made of any instances where elements of the design have not been implemented or have been implemented improperly.

6.1.7 Logic Representation

The purpose of this activity is to produce an alternative representation of the logic in the design and compare it to that of the developer. This alternate representation should be in a form that can be compared to that of the developer. A different method of generating the logic representation than that used by the developer should be used. The primary purpose of this alternative representation is to independently produce a logic structure that can be compared to that of the developer. This technique enables the verifier to identify the required logical paths.

The ARWA V&V team will use Computer Aided Software Engineering (CASE) tools when appropriate to assist in the conversion of logical process descriptions into computer methods. CASE tools may also be used by the developer to create reports and to develop tests for the simulator software segment from the computer-based requirements and design data. If a developer uses CASE tools then the V&V team will adopt consistent and compatible verification methods.

6.2 CODE VERIFICATION

Once the logic of the design has been verified, coding can begin. The following paragraphs describe the activities required to verify the coding for each software segment. These activities can be performed in conjunction with code development. Indeed, performing walk-throughs and peer reviews early in the coding phase is a good method for enforcing coding standards, as well as establishing points of contact within the development organizations.

The Detailed Software and Interface Design Documents will be reviewed during coding and unit test and integration testing phases. This review compares the SDD and IDD products as they are developed and controlled by the segment contractor, against the SRS and IRS to assure that no software or interface design feature exists that can not be matched to a corresponding requirement. Source code will be compared to the SRS, Detailed Software and Interface Design Documents. The goal as before is to assure that all requirements have been addressed and that no software or interface feature is implemented in the code which can not be matched to a corresponding requirement. SPARTA will also check that the contractor is following his coding standards as stated in the developer's Software Standards and Procedures as defined in his Software Development Plan.

The Software Test Descriptions (STDs) will be reviewed prior to the Test Readiness Review (TRR). STDs are defined prior to CDR and are further refined by defining the test procedures prior to TRR. The V&V team will identify the specific test

cases and detailed procedures which will provide complete and objective evidence that the unit under test meets its requirements.

The Software Test Reports are compared to the SRS and IRS to ensure that all planned test and procedures are documented with results. The goal of this review is to determine that all test were exercised or explanations are present and that the results provided sufficient objective evidence that the unit under test meets its requirements.

6.2.1 Code Walk-throughs

After the code has been written for each software segment, the V&V team will examine the code, module by module, to ensure efficiency, correctness, and completeness of implementation. The V&V team will check to see that all logic, algorithms, and equations have been properly implemented and that the interfaces between modules have been properly established.

The interfaces with other modules that represent other elements of the total simulation will be closely reviewed. The most obvious thing to look for is that all required inputs are present or all required data is encapsulated in the module. For example, to obtain a lock-on, a seeker may require that its missile be selected, the target be designated, the laser designation code match that of the weapon, the designated point be within the seeker's field of regard, and range and atmospheric conditions be such that the seeker detects the reflected radiation. Clearly, if any of the inputs associated with these conditions is missing, the model will not work correctly. The output is of equal importance, since output parameters will indicate whether or not the specification was understood. The output in this case is simple—either the seeker has a lock-on or it does not (assuming that position and angular data defining the designated point comes from another module).

The V&V team will properly document these walk-throughs, with particular note being made of any deficiencies found or any changes in implementation and the reason for them.

6.2.2 Peer Review

The purpose of this review, which is conducted by independent subject-matter experts, is to analyze modeling assumptions and to determine their implications. This may be done either in the form of presentations or by documentation review. The outputs of the review will be documented and fed back to the developers, as appropriate. The ARWA V&V team will supplement its V&V team with recognized subject-matter experts to perform this task.

6.2.3 Units Check

The ARWA V&V team will perform a units check in conjunction with design and code walk-throughs to ensure that units have been properly defined in the design and code implementations.

6.2.4 Logic Representation

The purpose of this activity is to produce an alternative representation of the logic in the code and compare it to that of the developer. This alternate representation should be in a form that can be compared to that of the developer. A different method of generating the logic representation should be used.

The ARWA V&V team will use Computer Aided Software Engineering (CASE) tools when appropriate to assist in the conversion of logical process descriptions into computer methods. CASE tools may also be used by the developer to create reports and to develop tests for the simulator software segment from the computer-based requirements and design data. If a developer uses CASE tools then the V&V team will adopt consistent and compatible verification methods.

6.2.5 Sensitivity Analyses

Sensitivity analyses basically involve testing the code to see that it behaves properly (the models are sensitive to the variables of interest) at the module, subsystem, and system levels. The V&V team will develop sets of nominal and boundary condition input data and will perform independent calculations (based on the governing logic and algorithms) to determine the expected results for each software element for each set of initial conditions. The code will then be run with the input data sets, and the results of the runs will be compared with results obtained from the independent calculations.

For example, in evaluating the radar model, we will check for proper implementation of the radar range equation and the impact of noise, clutter, and jamming to the extent that the effects of these factors are to be modeled. Since detection range (output) is a strong function of all of these parameters plus the radar cross-section of the target, the radar mode, and the geometry of the problem (input), the system will have to be evaluated under many conditions in order to verify that it works according to specification and, more importantly, works in a realistic manner.

The V&V team should expend a great deal of effort in developing as many data sets as possible in order to evaluate as many sets of conditions as possible. The results of all testing will be well documented and deficiencies noted, as will the results of follow-up testing after snags have been worked off.

6.2.6 Statistical Tests for Stochastic Models

The ARWA V&V team will design statistical tests for stochastic models when the model output is not deterministic, i.e. output is not repeatable or is dependent on random processes beyond the control of testers. Subject matter experts are often needed to determine if results are "within reason or expectation." The V&V team will use such experts when appropriate. The V&V team will test those algorithms which contain this type of processing to ensure that outputs follow the intended distributions.

6.3 SPECIFIC VERIFICATION ACTIVITIES

6.3.1 VSM

SPARTA will verify that the design, logic, and code of the Visual System Module (VSM) will provide visual and sensor image generation, moving models, lighting, environmental scene generation, crew station interfaces, and out-the-window displays as specified. The Visual System Module (VSM) computer image generation (CIG) system (an ESIG-2000) will dedicate one of its channels to producing the FLIR image. The task is to verify that the ESIG-2000 properly generates IR images of the terrain and moving models.

SPARTA does not have any means of generating IR imagery from the terrain and moving model data bases. We could use FLIR90 to generate minimum resolvable contrast (MRC) and minimum resolvable temperature differences (MRTDs) of selected targets at selected ranges, at selected aspect angles against selected backgrounds at selected times of day and season. We would then have to extract the digital image from the ESIG-2000 under the same selected conditions (I don't know if that's possible). The extracted image could then be analyzed to determine if the ESIG-2000 correctly transformed the terrain and moving model 3D representations into 2D IR images.

Table 6.3.1 shows the logic and code verification activities that are to be performed during each development phase for this component.

Activity: / Phase:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.1 Logic and Code Verification Activities for the VSM

6.3.2 FSM

6.3.2.1 FSM Base

Table 6.3.2.1 shows the logic and code verification activities that are to be performed during each development phase for this component.

Activity: / Phase:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.2.1 Logic and Code Verification Activities for the FSM Base

6.3.2.2 FSM Comanche

Cockpit
- Base control loading
  - collective
  - cyclic
  - foot pedals (toe brakes only)
- Cockpit pilot instrument panel
- Cockpit co-pilot/gunner instrument panel

Table 6.3.2.2 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.2.2 Logic and Code Verification Activities for the FSM Comanche

6.3.2.3 FSM Longbow

Cockpit
- Base control loading
  - collective
  - cyclic
  - foot pedals
- Cockpit pilot instrument panel
- Cockpit co-pilot/gunner instrument panel

Table 6.3.2.3 shows the logic and code verification activities that are to be performed during each development phase for this component.

Activity: / Phase:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.2.3 Logic and Code Verification Activities for the FSM Longbow

6.3.3 SSM

6.3.3.1 RAH-66 Comanche Kit

6.3.3.1.1 RAH-66 Flight Controls

The following are the requirements for the Flight Controls from the System/Segment Specification:

"The flight controls segment shall simulate the flight controls for the RAH-66 aircraft. Simulations shall include primary controls, trim, hinge moments, automatic flight controls systems (AFCS), miscellaneous control devices, and toe brakes/anti-skid. The flight controls simulation shall also include the ability to set and/or adjust certain device parameters including maximum pitch, roll and yaw rates: turning radius; flight controls input sensitivity; number of blades; no tail rotor effect on performance; and stochastic failures from combat and crash damage tables."

"The surface positions shall be determined from the cockpit control device inputs (cyclic stick, collective stick and directional pedals), AFCS inputs, hydraulic pressures, electrical power, and malfunction (battle damage) data. The primary controls function shall include the simulation of surfaces or controls such as actuators, swashplates and blade pitch (main and tail). The control loading system shall drive the primary control input devices (cyclic stick, collective stick and directional pedals) to provide the proper control feel for the pilot. This includes the effects of cyclic trim or force trim. In the case of the

RAH-66, only the collective stick and the brake pedals shall require force loading on the controls. This shall include simulation of the artificial feel system and friction, spring forces, deadband, inertia and hysteresis appropriate to each control input device. The force servo closed-loop response shall be stable and rapid enough to provide realistic dynamic feel. The control loading system shall have dynamic responses which are sufficiently realistic to prevent distraction of the pilot and to ensure that the pilot remains combat effective."

"The "cyclic trim" or "trim feel" function shall be modeled for the baseline air vehicles with the exception of the RAH-66. This shall include the force acting on the cyclic stick and directional control pedals to center and provide an artificial feel of being in a trim state."

"A simulation of hinge moments acting on the aerodynamic control surfaces of the baseline aircraft shall be provided, if necessary, and shall restrict movement of those aerodynamic surfaces appropriately."

"The AFCS simulation shall provide the capabilities of heading hold, pitch hold, roll hold, attitude hold, hover hold, and velocity stabilization as required for each air vehicle configuration according to Figure 3.1.1.1.1.4-1. Stability augmentation simulations shall provide improved stability in the pitch, roll and yaw axes by providing aircraft damping. The stability augmentation system shall oppose any deviation in attitude, but shall not return the aircraft to a given attitude or heading. The simulation shall provide for stability augmentation to be engaged at all times in pitch, roll and yaw mode. Sensed rate signals and Central Air Data Computer (CADC) inputs shall be used in determining pitching, rolling, or yawing motion."

"Miscellaneous controls including stabilator position, landing gear positions, weapon bay door positions, and tail wheel locked status shall be simulated. The normalized positions and states (e.g., open, opening, closed, etc.) of the miscellaneous control devices shall also be determined."

"The simulation of braking effects shall be modeled for the RAH-66 aircraft. The RAH-66 simulation shall use brake pedals mounted on foot rests. The effects required to be supplied during braking operation shall include brakes on and off."

RAH-66

Simulate primary controls determined by cyclic and collective controls:
- main rotor actuators and surface positions
- fantail actuators and surface positions

Simulate automatic flight controls system (AFCS) by modeling AFCS control laws to provide:
- stability augmentation
- trim hold
- selectable capabilities from Table 6.3.3.1.1-1 below:

Pitch Hold	Roll Hold	Yaw Hold	Attitude Hold	Hover Hold	Velocity Stabilization
Y	Y	Y	Y	Y	Y

Table 6.3.3.1.1-1 RAH-66 Flight Controls Selectable Capabilities

Simulate Flight Director

Simulate flight director to provide steering commands to the pilot and to the AFCS to obtain fire control solutions when operating in the Integrated Fire/Flight Control mode, or to provide steering commands to the pilot and AFCS to obtain navigation waypoint steering when in the Coupled Navigation mode.

Check the design, logic and code in the following areas to verify that the segment will perform as specified:

- primary controls simulation of:
  - control laws
  - main rotor and fantail actuators and surface positions determined from the cockpit control devices (cyclic and collective controls)
  - trim inputs
  - aircraft state information
  - AFCS inputs
  - hydraulic pressures
  - electrical power
  - battle damage
  - cyclic inputs (longitudinal, lateral, directional stick commands) and the collective stick command provided by the Digital Control Loading (DCL) hardware
  - limited vertical stick command provided by the DCL
  - DCL simulation of the force feel characteristics of the left hand collective, provision of analog voltage for the right hand sidearm controller (cyclic), and backdrive of the collective
- automatic flight controls system:
  - simulation of the AFCS control laws to provide stability augmentation, trim hold and selectable capabilities
  - interface with the flight director function to provide coupled navigation and integrated fire control
- flight director simulation of the ability of the RAH-66 aircraft to perform integrated fire/flight control and coupled navigation
- miscellaneous control devices simulation of the extension/retraction of the landing gear and opening/closing of the landing gear doors
- ability to set and/or adjust the flight controls segment adaptability parameters
- degradation of flight controls operation due to battle damage based on severity and location of damage

Table 6.3.3.1.1-2 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.3.1.1-2 Logic and Code Verification Activities for RAH-66 Flight Controls

6.3.3.1.2 RAH-66 Nav/Comm

<u>HARS/AHRS</u>

The same approach used for the AH-64D will be used for the RAH-66.

Provides helicopter attitude outputs for pitch, roll, heading, velocities, and accelerations as required by other ownship systems.

<u>DNS</u>

The same approach used for the AH-64D will be used for the RAH-66.

From the System/Segment Specification: "Radio Navigation Aid System. The ASN-137 Doppler Navigation System (DNS) will be controlled through the Computer Display Unit (CDU) IP-1552/G. Simulation of DNS accuracy degradation due to altitude and high pitch and roll angles is not required. The Navigation mode of the ASN-137 model shall be functional. Modes such as backup, Hover Bias Calibration, and Test modes are not required. All CDU (or MFD) pages shall be accessible through the proper use of key selections and data entry and the display shall be simulated. Navigation data required to provide steering commands shall be dependent upon pilot data entry. Simulation of the Fault Detection/Location System (FD/LS) function is not required."

<u>GPS</u>

The same approach used for the AH-64D will be used for the RAH-66.

"A generic Global Positioning System (GPS) shall be modeled to provide accurate position and velocity information for use by other systems."

"This information will be derived from the equations of motion in the Flight Dynamics segment, then modified to account for electrical system status, battle damage, and adaptability parameters."

ICS (Intercommunications System)

C11746/ARC

VHF COMMS (FM and AM)

ARC-186

UHF COMMS

ARC-164

Voice communications capabilities of the above subsystems are summed into one segment to provide the required communication capabilities. The following was taken from the System/Segment Specification and describes the required communications functionality.

"Voice reception from crewmembers and other vehicles shall be possible at all times as long as the receiver select switches on the ICS panel are on, the volume is turned up, and LOS is possible. The simulation shall provide for monitoring of up to five radios. The transmit selector switch shall be active in the RMT position only, allowing the pilot to select the desired radio to transmit on from the remote transmitter select switch on the cyclic stick. The Hot Mic and Mic switches functions are not required. Nav audio (Automatic Direction Finder (ADF) or Identification Friend or Foe (IFF)) monitoring are not required. A communication link shall be provided to provide voice reception and transmission to the Commander's workstation in the TOC."

"The pilot and CPG ARC-186 VHF radios shall be functional in AM and FM modes. D/F mode simulation is not required. Frequency selection shall be functional in the manual and preset modes but not in emergency mode. Squelch control or tone select functions are not required. Insertion of static and noise due to equipment interference, atmospheric conditions, or range is not required. The ability to receive communications shall be dependent on line of sight and proper operation of the VHF control panel and ICS panel selections. VHF communications volume shall not be controlled from the ARC-186 panel."

"The pilot's ARC-164 UHF radio shall be fully functional, including the guard receiver. Squelch control, and tone select functions do not require simulation. The HAVEQUICK function does not require simulation. Insertion of static and noise due to equipment interference, atmospheric conditions, or range is not required. The ability to receive communications shall be dependent on line of sight and proper operation of the VHF control panel and ICS panel selections."

AIR DATA

ADSS (Air Data Sensor System)

Provide the following information to the other ownship systems:

- calibrated and indicated airspeed
- temperature, static pressure, and all air mass data

- height above mean sea level

The above data is modified based on power status, battle damage, and on/off adaptability parameter.

ATHS

(Airborne Target Handover System)

"The ATHS shall be simulated and shall interface properly through the Communications system. ATHS communications shall be possible between all appropriately equipped aircraft and the Commander's workstation in the Tactical Operations Center (TOC)."

MOVING MAP

"The RAH-66 moving map system and all associated controls shall be simulated. The map control, map navigation, map tactical, and map scale function shall be simulated. Overlay options as required by these functions shall be simulated. Aircraft position data provided to the map system will be obtained from the appropriate navigational source."

Table 6.3.3.1.2 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				√

Table 6.3.3.1.2 Logic and Code Verification Activities for RAH-66 Nav/Comm

6.3.3.1.3 RAH-66 Weapons

The following assumptions were made by Boeing for the Comanche weapons. If requirements exist, validation of multiple Hellfire systems will be performed for the Comanche. See Boeing's section of the PMR No. 2 briefing. Similar assumptions will be made for the Longbow weapons:

- no simulated gun barrel wear

- thrust misalignment due to down wash only
- yaw and projectile drift not simulated
- port-starboard errors not simulated
- perfect gunsights
- no vibration errors

The System / Segment Specification for the RAH 66 states the aircraft has two gun systems but the aircraft should only have one gun onboard and available for use. We have therefore defined two gun system options in describing the verification and validation efforts on the weapons systems.

Check the design, logic and code in the computation of ownship combat damage. Determine that the probabilities of kill and damage are properly computed as a function of the weapon (warhead) and its detonation location relative to predefined aircraft zones.

VULCAN II 20mm Gun

Represent trajectory of ballistic projectile using a flyout table. Aerodynamic modeling not required. Generate dispersion pattern of multiple rounds centered on a simulated single projectile.

Compare flyout and dispersion patterns logic to the logic implemented in the model INCURSION embedded in ALWSIM.

Check the design, logic and code in the following areas to verify that the system will perform as specified:

- bullets can be loaded and the number of rounds is properly displayed
- gun can be selected and armed (master arm)
- gun correctly positioned (AUTO/CLOSED/LOAD/DEPLOY)
- gun can be targeted within correct azimuth and elevation limits
- gun can be fired - trigger 1st and 2nd detent operation
- rounds remaining decreases properly
- bullets follow proper trajectory and impact about targeted point
- compute all data required by Environment segment for DIS PDUs

NEEDED: VULCAN II 20mm Gun capabilities description

2.75" FFAR MK-66

Represent trajectory of each powered projectile using a flyout table. Aerodynamic modeling not required. Generate dispersion pattern centered on projectile trajectory.

Compare flyout and dispersion patterns logic to the logic implemented in the model INDIRECT FIRE EFFECTS embedded in ALWSIM.

Check the design, logic and code in the following areas to verify that the system will perform as specified:

- rockets can be loaded and the number of rounds is properly displayed
- rockets can be selected and armed (master arm)
- rockets can be properly targeted
- rockets can be fired - trigger 1st and 2nd detent operation
- number remaining decreases properly
- rockets follow proper trajectory and impact about targeted point

- compute all data required by Environment segment for DIS PDUs

NEEDED: 2.75" FFAR MK-66 capabilities description

HYDRA 70

Represent trajectory of each powered projectile using a flyout table. Aerodynamic modeling not required. Generate dispersion pattern centered on projectile trajectory.

Compare flyout and dispersion patterns logic to the logic implemented in the model INDIRECT FIRE EFFECTS embedded in ALWSIM.

Check the design, logic and code in the following areas to verify that the system will perform as specified:

- rockets can be loaded and the number of rounds is properly displayed
- rockets can be selected and armed (master arm)
- rockets can be properly targeted
- rockets can be fired - trigger 1st and 2nd detent operation
- number remaining decreases properly
- rockets follow proper trajectory and impact about targeted point
- compute all data required by Environment segment for DIS PDUs

NEEDED: HYDRA 70 capabilities description

AGM-114A LASER HELLFIRE

Represent trajectory of each powered missile using a flyout table. Aerodynamic modeling not required. Model acquisition probability as a function of

- range to target
- laser range to target
- reflected energy
- background

Use PHI model in ALWSIM for laser target acquisition probability comparison.

Use ALWSIM flyout logic for comparison to HELLFIRE flyout.

Check the design, logic and code in the following areas to verify that the system will perform as specified:

- missiles can be loaded and the number of rounds is properly displayed
- missiles can be selected in desired sequence and armed (master arm)
- missiles can be properly targeted to obtain "SHOOT" cue
  - target within kinematic range of missile
  - target must be designated with correct code
  - target can be designated autonomously or remotely
  - seeker must acquire (function of range/weather, CLOS)
  - designated target within seeker azimuth and elevation FOV limits
  - aircraft launch constraints must be met
  - indirect fire and lock-on-after-launch modes
- missiles can be fired - trigger 1st and 2nd detent operation
- missiles fire in selected order
- number remaining, and their location, properly displayed
- missiles follow proper trajectory and impact target
- compute all data required by Environment segment for DIS PDUs

NEEDED: AGM-114A LASER HELLFIRE capabilities description

Air To Air Stinger (ATAS)

Represent trajectory of each powered missile using a flyout table. Aerodynamic modeling not required. Model acquisition probability as a function of range to target, minimum resolvable contrast (MRC), and minimum resolvable temperature differences (MRTDs). Model kill probability using above information.

Use FLIR90 model in ALWSIM for IR target acquisition, tracking, and end-game probability comparison.

Use ALWSIM flyout logic for comparison to ATAS flyout.

Check the design, logic and code in the following areas to verify that the system will perform as specified:

- missiles can be loaded and the number of rounds is properly displayed
- missiles can be selected in desired sequence and armed (master arm)
- missiles can be properly targeted to obtain "SHOOT" cue
    - seeker must acquire (function of range/weather, CLOS, target IR intensity)
    - seeker slaves to targeting system
    - designated target within seeker azimuth and elevation FOV limits
    - seeker provides cue for tone
- missiles can be fired - trigger 1st and 2nd detent operation
- missiles fire in selected order
- number remaining, and their location, properly displayed
- missiles follow proper trajectory and impact target
- compute all data required by Environment segment for DIS PDUs

NEEDED: Air To Air Stinger capabilities description

Table 6.3.3.1.3 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				√

Table 6.3.3.1.3 Logic and Code Verification Activities for RAH-66 Weapons

6.3.3.1.4 RAH-66 Sensors

NVPS (Based on the AN/AAQ-1? FLIR PNVS)

The Visual System Module (VSM) computer image generation (CIG) system (an ESIG-2000) will dedicate one of its channels to producing the FLIR image. The task is to validate that the ESIG-2000 properly generates IR images of the terrain and moving models.

SPARTA does not have any means of generating IR imagery from the terrain and moving model data bases. We could use FLIR90 to generate minimum resolvable contrast (MRC) and minimum resolvable temperature differences (MRTDs) of selected targets at selected ranges, at selected aspect angles against selected backgrounds at selected times of day and season. We would then have to extract the digital image from the ESIG-2000 under the same selected conditions (I don't know if that's possible). The extracted image could then be analyzed to determine if the ESIG-2000 correctly transformed the terrain and moving model 3D representations into 2D IR images.

EOTADS (or TAS)

The following assumptions were made by Boeing for the Comanche EOTADS. See Boeing's section of the PMR No. 2 briefing. I am assuming that similar assumptions will be made for the Longbow AN/AAQ-170 TADS.

- target detection and classification shall be probabilistically determined as a function of range to target, visibility, and adaptability parameters (see Faxed material)
  - -- frequency
  - -- etc.
- target prioritization shall be a function of sensor ID, target type, and range
- laser range error will be a function of the adaptability parameter

Table 6.3.3.1.4 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				√

Table 6.3.3.1.4 Logic and Code Verification Activities for RAH-66 Sensors

6.3.3.1.5 RAH-66 ASE

Radar Warning APR-39 (V)1 (V)2

Simulate RF emitter detection and identification performed by the Radar Warning Receiver (RWR).

Provide receiver status, RF indications, and alerts to the FSM.

RF indications include detection range and parameter limit detection (frequency, PRF, and PW).

The intent is to characterize the performance of the RWR by defining the following adaptability parameters:

- frequency
- PRF (pulse repetition frequency)
- PW (pulse width)
- FOV (field of FOV)
- detection range
- direction finding

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the radar warning adaptability parameters; EID file; threat emitter type, location, power, mode, and beam characteristics; and ownship location and orientation:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensors
- identification in accordance with EID file and emitter beam parameters

- maximum detection range and range estimate from ID, EID file and detected power
- detection/no detection from maximum range and threat and ownship locations
- coarse radar site list for radar warning receiver and radar jammer operation
- emitter mode (search, acquisition, track, or missile activity) from EID file and emitter beam characteristics and activity
- emitter relative bearing from AOA information and ownship heading
- emitter priority based on priority in EID file, detecting equipment and range
- emitter location based on range and bearing
- emitter location based on triangulation processing by multiple team members
- radar warning indications (up to 8 visual effects and up to 5 visual effects), prioritized target list and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the radar warning adaptability parameters

NEEDED: APR-39 (V)1 (V)2 capabilities description.

Radar Jammer ALQ-136 (V)1/5

Simulate the matching of detected RF emitter to jamming signal.
Identify detection range and parameter limits.
Provide radar jammer status to the FSM.
Provide the interface to the DIS network protocols for the transmitted RF signal(s).

The intent is to characterize the performance of the jammer by defining the following adaptability parameters:

- frequency
- power
- technique
- FOV (field of FOV)
- jam range

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the radar jammer adaptability parameters; EID file; course radar site list; and ownship location and orientation:

- equipment functional status from electric power indications, ECM enable status and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or antennas
- emitter detected if on course radar site list generated by radar warning receiver
- emitter prioritized in accordance with EID file and range between emitter site location and ownship location
- AOA evaluations using ownship angular position values, actual earth axis azimuth and elevation to the emitter, and EID file error indications
- radar jamming parameters using results of the AOA evaluations, the RF emitter's beam parameters and the EID file jamming indications
- RF jamming characteristics required to effectively simulate the jamming of the selected emitters (up to 10) and other interface parameters computed and passed

- jamming characteristics can be modified within the limits of the radar jammer adaptability parameters

NEEDED: ALQ-136 (V)1/5 capabilities description.

Laser Warning AVR-2 (V) TBD

Simulate laser emitter detection and identification performed by the Laser Warning Receiver (LWR).

Provide receiver status, laser indications, and alerts to the FSM.

The intent is to characterize the performance of the LWR by defining the following adaptability parameters:

- frequency
- PRF (pulse repetition frequency)
- PW (pulse width)
- FOV (field of FOV)
- detection range

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the laser warning adaptability parameters; laser ID file; laser type, location, power, code, and beam characteristics; and ownship location and orientation:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensors
- identification in accordance with laser ID file and laser beam parameters
- maximum detection range and range estimate from ID, laser ID file and detected power
- detection/no detection from maximum range and laser and ownship locations
- laser code from laser ID file and laser beam characteristics
- laser relative bearing from AOA information and ownship heading
- laser priority based on priority in laser ID file and range
- emitter location based on range and bearing
- emitter location based on triangulation processing by multiple team members
- laser warning indications (up to TBD visual effects and up to TBD visual effects), prioritized target list and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the IR warning adaptability parameters

NEEDED: AVR-2 (V) capabilities description.

IR Jammer ALQ-144 (V)1/3

Simulate IR jamming characteristics: power, frequency, field of view.

Provide IR jammer status to the FSM.

Provide the interface to the DIS network protocols.

The intent is to characterize the performance of the IR jammer by defining the following adaptability parameters:

- frequency
- power

- technique

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the IR jammer adaptability parameters; IR jammer characteristics; location of IR seeker; and ownship location:

- equipment functional status from electric power indications, ECM enable status and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or IR element
- IR jamming parameters for simulation of the cooldown and warmup cycling technique
- IR jamming characteristics and other interface parameters computed and passed
- jamming characteristics can be modified within the limits of the IR jammer adaptability parameters

NEEDED: ALQ-144 (V)1/3 capabilities description.

Radiation Warning System (RWS)

Simulate radiation detection and identification performed by the Radiation Warning System (RWS).

Provide detector status, radiation indications, and alerts to the FSM.

The intent is to characterize the performance of the RWS by defining the following adaptability parameters:

- sensitivity of detectors
- detector pattern
- detection azimuth

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the radiation warning adaptability parameters; radiological ID file; radiation type, location, source intensity; and ownship location:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensor
- detectable/not detectable from radiation type
- intensity level at ownship from source intensity and range between radiation source location and ownship location
- detection/no detection from radiation ID file detection threshold and radiation intensity level at ownship
- radiological alert indication and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the radiation warning adaptability parameter

NEEDED: RWS capabilities description.

Chemical Warning System (CWS)

Simulate chemical agent detection and identification performed by the Chemical Warning System (CWS).

Provide detector status, agent indications, and alerts to the FSM.

The intent is to characterize the performance of the CWS by defining the following adaptability parameters:

- sensitivity
- detector pattern
- catalog of known agents characteristics

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the chemical warning adaptability parameters; chemical ID file; chemical type, cloud center location, cloud radius, cloud density; and ownship location:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensor
- detectable/not detectable from chemical type
- ownship within/not within chemical cloud based on cloud radius, cloud center location and ownship location
- detection/no detection from chemical ID file detection threshold and chemical density level at ownship
- chemical alert indication and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the chemical warning adaptability parameters

NEEDED: CWS capabilities description.

Chaff M-I M-130 Dispenser. This capability is not currently required by the RAH-66. It is provided here for information purposes only.

Simulate chaff loading.

Simulate chaff release.

Simulate chaff system status and inventory.

Simulation of dispensed chaff characteristics to the extent to provide interface to the DIS network protocols.

We have not identified a validated source of chaff characteristics.

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the chaff adaptability parameters; pilot switch selection and actions; and ownship location:

- equipment functional status from electric power indications, chaff inventory, chaff selection and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or dispenser
- *chaff dispensed upon command when manual mode selected*
- chaff dispensed in accordance with system characteristics or adaptability parameters when automatic mode selected
- chaff inventory decremented by the number of bundles dispensed
- release indication and other interface parameters computed and passed
- delivery system characteristics and/or chaff characteristics can be modified within the limits of the chaff adaptability parameters

NEEDED: Chaff M-I capabilities description.

Flare M-206 M-130 Dispenser. This capability is not currently required by the RAH-66. It is provided here for information purposes only.

Simulate flare loading.

Simulate flare release.

Simulate flare system status and inventory.

Simulation of dispensed flare characteristics to the extent to provide interface to the DIS network protocols.

We have not identified a validated source of flare characteristics.

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the flare adaptability parameters; pilot switch selection and actions; and ownship location:

- equipment functional status from electric power indications, flare inventory, flare selection and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or dispenser
- flares released upon command when manual mode selected
- flares released in accordance with system characteristics or adaptability parameters when automatic mode selected
- flare inventory decremented by the number of flares dispensed
- release indication and other interface parameters computed and passed
- delivery system characteristics and/or flare characteristics can be modified within the limits of the flare adaptability parameters

NEEDED: Flare M-206 capabilities description.

Table 6.3.3.1.5 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				√

Table 6.3.3.1.5 Logic and Code Verification Activities for RAH-66 ASE

6.3.3.1.6 RAH-66 Flight Dynamics

From the System/Segment Specification:

"The Flight Dynamics segment shall provide for a realistic simulation of the flight characteristics of the simulated aircraft. The simulation shall include portions of the flight envelope which reflect combat operations such as: cruise, ascent, descent, hover, low-level (i.e., within ground effect) flight, approach and landing within a refueling/rearmament zone and subsequent takeoff from that zone. The simulation shall reproduce fidelity of flight operations to a level which will closely resemble that of the selected aircraft and which will not cause either distraction of the pilot or an increase or decrease in the performance of the air vehicle to an extent that would affect combat effectiveness or associated test results. The simulation shall include forces and moments, equations of motion, weight and balance, envelope violation, aerodynamics and ground handling. The flight dynamics simulation shall also include the ability to set and/or adjust certain device parameters to include maximum speed, fuel load time, maximum pitch, roll and yaw rates, turning radius, turret and hull separation distance, number of blades and no tail rotor effect on performance, failures from combat and crash damage, gross weight limitations, external fuel tanks, weapons selection, wing stores, internal stores configuration and load time for ammunition."

Check the design, logic and code in the following areas to verify that the segment will perform as specified:

- rotor aerodynamics computation of the forces, moments and torques generated by the main rotor and fantail during all modes of operation
- airframe aerodynamics computation of the aerodynamics forces and moments generated by the airframe (i.e., fuselage, vertical tail, horizontal stabilizer, landing gear and doors)
- ground handling computation of the vertical force generated by the interaction of the aircraft landing gear with the ground
- mass properties computation of aircraft gross weight, center of gravity position, and moments and product of inertia
- total forces and moments computation of the total forces and moments acting on the aircraft in the body axis coordinate system
- envelope violation monitoring capability of critical flight parameters to determine if the structural capabilities of the aircraft have been exceeded resulting in a crash condition
- equations of motion computation of aircraft state, which include linear and angular positions, velocities, and accelerations in both the body and earth axis coordinate systems
- ability to set and/or adjust the flight dynamics segment adaptability parameters
- simulation of the effect of changes in the physical configuration/position of the aircraft fuselage components and degraded flight performance due to battle damage

Table 6.3.3.1.6 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.3.1.6 Logic and Code Verification Activities for RAH-66 Flight Dynamics

6.3.3.1.7 RAH-66 Propulsion

T800 Engine Simulation

Simulate rotor torque/speed function
- main rotor speed
- tail rotor speed
- transmission oil temperature and pressure

Simulate gas generator function
- gas generator speed
- power turbine speed
- engine oil temperature and pressure
- engine torque

Simulate engine fuel function
- fuel rates
- turbine gas temperature

Approach to simulation:

Engine oil temperature and pressure are initialized and held constant unless battle damage has occurred.

Transmission oil temperature and pressure are initialized and held constant unless battle damage has occurred.

Power turbine speed is initialized and held constant unless battle damage has occurred.

Check the design, logic and code in the following areas to verify that the segment will simulate the engines and transmission of the RAH-66 as specified:

- rotor torque/speed as a function of the torque requirements generated in the flight dynamics section
- engine fuel burn rate as a function of torque output and gas turbine speed
- gas generator core speed modulation to maintain the 100% rotor speed demand
- ability to set and/or adjust the propulsion segment adaptability parameters
- simulation of the reactions to, and indications of, sustained battle damage

Table 6.3.3.1.7 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.3.1.7 Logic and Code Verification Activities for RAH-66 Propulsion

6.3.3.1.8 RAH-66 Physical Cues

"The Physical Cues segment shall simulate the environmental sounds, navigation system tones and threat audio tones for each of the RAH-66 aircraft. The simulated sounds shall include engines, rotors, small arms impacts, ownship weapons firings and weapon detonation,. Simulated tones shall include aircraft warning system synthetically generated tones, radar induced tones, and navigation systems tones. The spectral content and loudness levels of these sounds and tones shall be dynamically controlled to represent realistic responses to simulated events. There shall be no motion system or motion cues provided."

SPARTA shall check the design, logic, and code to verify that these function are implemented as specified.

Table 6.3.3.1.8 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.3.1.8 Logic and Code Verification Activities for RAH-66 Physical Cues

6.3.3.1.9 RAH-66 TNE

The Tactical and Natural Environment segment will receive special attention for, through it, the ARWA SS interfaces with the rest of the Multiple Simulator Environment (MSE). And since these data then flow to and from the other segments of the RAH-66 Simulator System Module, in order to interact with/stimulate their models, the proper implementation and functioning of the TNE segment is crucial to the proper functioning of the entire RAH-66 Simulator System Module. Verification will require a check of the design, logic and code in the following areas to verify that the segment will operate as specified:

TNE Segment Support Function
- Execuive Control support service which provides operational control for the TNE segment
- Initialization support service which controls initial hardware and software states for the TNE segment
- ARWA SS Inter-Segment Communication support service which provides the TNE segment interface through the ARWA SS architecture

Atmosphere Function
- Provides ambient atmospheric data as a function of altitude
- Provides the specific atmospheric model
- Provides commanded atmospheric effects such as wind and turbulence

Database Management Function

- Provides control of the ARWA SS databases before, and during, a real-time experiment. This function shall:
  - filter out those entities which are beyond a specified range in order to reduce the scope of actively modeled entities
  - process logical and data faults around the gaming areas
  - provide the management of dynamic database elements, as a minimum, the location of platform entity crash sites
  - maintain a list of the terrain and culture points within the gaming area that have been damaged, or otherwise affected, in a real-time exercise
  - the reference database provides the background terrain and culture definition required for resolution of spatial relations, occulting, etc.

Spatial Relations Function

- Provides models that characterize the relationship between a vehicle and elements of the natural and tactical environment. This function will:
  - determine the slant range from a specified entity to natural and tactical entities in the gaming area
  - calculate height above terrain, for a specified entity, based upon the terrain characteristics contained in the terrain database
  - detect the occurrence of collisions between a specified entity and entities or terrain with which it can collide

Occulting Function

- Determines the line-of-sight continuity between any object or designated area and the ownship, or for other objects in the simulation

Entity Management Function

- Simulates the physical characteristics of all active platforms in a real-time experiment.
  - it shall use the appropriate dead reckoning algorithms, as defined by the MSE for each entity generated by the MSE, to update their position and attitude between update messages
  - it shall integrate the updated information about the entity state in order to produce a seamless simulation of the entity within the ownship

Entity Database Function

- Provides an extensive and detailed description of the non-ownship entities that may be active in an experiment. It shall also provide for the generation and maintenance of the entity data.

Entity Weapons Function

- Simulates the firing and flight track of weapons detectable to the ownship during a real-time experiment. It shall:
  - activate, fly and deactivate non-ownship weapons in accordance with instructions from the Entity Management function
  - model all of the control and operation parameters for weapon entities, based on control requests
  - accept command, control and position information from the MSE Interaction function describing weapons which are created and controlled by other simulators in the MSE

- integrate this information into a seamless simulation of weapon entities
- model the flight path fidelity of weapon entities
- model the mass properties of weapon entities

Entity Expendable Countermeasure Function

- Simulates deployment of expendable countermeasures (e.g. chaff and flares) from non-ownship platforms during an experiment. Expendable countermeasures dispensing will be controlled by other simulators.

MSE Interaction Function

- Provides the communication protocol and data formats required for interaction between the TNE segment and the MSE.
    - The MSE interaction function shall provide all formatting, conversion, and communication required for the TNE segment to communicate within the MSE
    - Communications shall use the DIS protocol
    - Communications between simulators in the MSE shall occur via DIS LAN.

Table 6.3.3.1.9 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6. Logic and Code Verification Activities for RAH-66 TNE

6.3.3.2 AH-64D Longbow Kit

6.3.3.2.1 AH-64D Flight Controls

The following are the requirements for the Flight Controls from the System/Segment Specification:

"The flight controls segment shall simulate the flight controls of the AH-64D. Simulations shall include primary controls, trim, hinge moments, Enhanced Digital Automatic Stabilization Equipment (EDASE), miscellaneous control devices, and toe brakes. The flight controls simulation shall also include the ability to set and/or adjust certain device parameters including maximum pitch, roll and yaw rates: turning radius; flight controls input sensitivity; number of blades; no tail rotor effect on performance; and stochastic failures from combat and crash damage tables."

"The surface positions shall be determined from the cockpit control device inputs (cyclic stick, collective stick and directional pedals), EDASE inputs, hydraulic pressures, electrical power, and malfunction (battle damage) data. The primary controls function shall include the simulation of surfaces or controls such as actuators, swashplates and blade pitch (main and tail)."

"The "cyclic trim" or "trim feel" function shall be modeled for the AH-64D. This shall include the force acting on the cyclic stick and directional control pedals to center and provide an artificial feel of being in a trim state."

"The hinge moments function shall provide a simulation of hinge moments acting on the aerodynamic control surfaces of the baseline aircraft, if necessary, and shall restrict movement of those aerodynamic surfaces appropriately."

"The EDASE simulation shall provide the capabilities of heading hold, attitude hold, hover hold, and altitude hold as required for the AH-64D. Stability augmentation simulations shall provide improved stability in the pitch, roll and yaw axes by providing aircraft damping. The stability augmentation system shall oppose any deviation in attitude, but shall not return the aircraft to a given attitude or heading. The simulation shall provide for stability augmentation to be engaged at all times in pitch, roll and yaw mode. Sensed rate signals and Air Data System (ADS) inputs shall be used in determining pitching, rolling, or yawing motion."

"The miscellaneous controls including stabilator position and tail wheel locked status shall be simulated by this function. The normalized positions and states (e.g., open, opening, closed, etc.) of the miscellaneous control devices shall also be determined by this function. The stabilator position for the AH-64 series helicopters simulation shall support manual and automatic control only."

"The simulation of braking effects shall be modeled for the AH-64D aircraft. The AH-64D shall use the top portion (toe) of the directional control pedals to provide the pilot control of the main gear brakes. The effects required to be supplied during braking operation shall include brakes on and off.."

Simulate automatic flight controls system (EDASE) by modeling EDASE control laws to provide:

- stability augmentation
- trim hold

- selectable capabilities from Table 6.3.3.2.1-1 below:

Pitch Hold	Roll Hold	Yaw Hold	Attitude Hold	Hover Hold	Velocity Stabilization
Y	Y	Y	Y	Y	n/a

Table 6.3.3.2.1-1 AH-64D Flight Controls Selectable Capabilities

Check the design, logic and code in the following areas to verify that the segment will perform as specified:

- primary controls
- automatic flight controls system
- flight director
- miscellaneous control devices
- ability to set and/or adjust the flight controls segment adaptability parameters
- degradation of flight controls operation due to battle damage based on severity and location of damage

Table 6.3.3.2.1-2 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.3.2.1-2 Logic and Code Verification Activities for AH-64D Flight Controls

6.3.3.2.2 AH-64D Nav/Comm

INU (Inertial Navigation Unit)

From the System/Segment Specification:

"The AH-64D INU simulation shall provide helicopter attitude outputs for pitch, roll, heading, velocities, and accelerations as required by other aircraft systems. Align mode control, alignment and self test simulation is not required.".

DRVS (Doppler Radar Velocity Sensor)
AN/ASN-157
From the System/Segment Specification:

"Radio Navigation Aid System. Simulation of DNS accuracy degradation due to altitude and high pitch and roll angles is not required. Modes such as backup, hover bias calibration, and test modes are not required. Simulation of the Initiated Built In Test (IBIT) function is not required."

GPS (Global Positioning System)
From the System/Segment Specification:

"A generic Global Positioning System (GPS) shall be modeled to provide accurate position and velocity information for use by other systems."

"This information will be derived from the equations of motion in the Flight Dynamics segment, then modified to account for electrical system status, battle damage, and adaptability parameters."

Communications
ICS (Intercommunications System)
C11746/ARC
VHF COMMS - AM
ARC-186
VHF COMMS - FM
ARC-201
UHF COMMS
ARC-164

Voice communications capabilities of the above subsystems are summed into one segment to provide the required communication capabilities. The following was taken from the System/Segment Specification and describes the required communications functionality.

"Voice reception from crewmembers and other vehicles shall be possible at all times as long as the receiver select switches on the ICS panel are on and the volume is turned up. The simulation shall provide for monitoring of up to five radios. The Hot Mic and Mic switches functions are not required. Nav audio (Automatic Direction Finder (ADF) or Identification Friend or Foe (IFF)) monitoring are not required."

"The ARC-186 VHF radios shall be functional in AM mode. D/F mode simulation is not required. Frequency selection shall be functional in the manual and preset modes but not in emergency mode. Squelch control or tone select functions are not required. Insertion of static and noise due to equipment interference, atmospheric conditions, or

range is not required. The ability to receive communications shall be dependent on line of sight and proper operation of the ICS panel selections."

"The ARC-164 UHF radio shall be fully functional, including the guard receiver. Squelch control, and tone select functions do not require simulation. The HAVEQUICK function does not require simulation. Insertion of static and noise due to equipment interference, atmospheric conditions, or range is not required. The ability to receive communications shall be dependent on line of sight and proper operation of the ICS panel selection."

"The ARC-201 VHF-FM radios shall be fully functional. Squelch control and tone selection functions do not require simulation. The SINCGARS function does not require simulation. Insertion of static and noise due to equipment interference, atmospheric conditions, or range is not required. The ability to receive communications shall be dependent on line of sight and proper operation of the ICS control panel selections."

AIR DATA

ADSS (Air Data Sensor System)

Provide the following information to the other ownship systems:

- calibrated and indicated airspeed
- temperature, static pressure, and all air mass data
- height above mean sea level

The above data is modified based on power status, battle damage, and on/off adaptability parameter.

IMPROVED DATA MODEM (IDM)

"The IDM shall be simulated and shall interface properly through the Communications system. IDM communications shall be possible between all appropriately equipped aircraft and the Commander's workstation in the Tactical Operations Center (TOC). The IDM system will enable composition, transmission and receipt of free text, RF handover, priority fire/no fire zones, battle damage assessments and other pertinent tactical data."

Table 6.3.3.2.2 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				√

Table 6.3.3.2.2 Logic and Code Verification Activities for AH-64D Nav/Comm

6.3.3.2.3 AH-64D Weapons

McDonnell Helicopter Systems has proposed two options for the modeling of weapon systems.

The first option is to use existing 5 DOF weapon models in the MDHC model library. These 5 DOF models were validated under a previous effort but have since been modified. This option would allow real-time trajectory generation and damage assessment.

The second option is to generate table driven, table look-up weapon flyout models derived from their existing 5 DOF model library. The 5 DOF models would generate the data for the required tables. The table driven models are being considered based on 1) the computational constraints of processing time available, and 2) ease of modification of the tabular data to meet experiment needs for proposed weapon systems.

The acceptance of these table driven models would be based on completion of all the following steps:

- review of the validated MDHC 5 DOF weapon trajectory models descriptions,
- comparison of the validated 5 DOF models with modified 5 DOF models,
- review of the previous V&V process, and
- review and understand the translation process from trajectory model to table driven model.

The following assumptions were made by Boeing for the Comanche weapons and are assumed for the Longbow as well. If requirements exist, validation of multiple Hellfire systems will be performed for the Comanche.

- no simulated gun barrel wear
- thrust misalignment due to down wash only
- yaw and projectile drift not simulated
- port-starboard errors not simulated
- perfect gunsights
- no vibration errors

Check the design, logic and code in the computation of ownship combat damage. Determine that the probabilities of kill and damage are properly computed as a function of the weapon (warhead) and its detonation location relative to predefined aircraft zones.

M-230E1 30mm Gun

Represent trajectory of ballistic projectile using a flyout table. Aerodynamic modeling not required. Generate dispersion pattern of multiple rounds centered on a simulated single projectile.

Compare flyout and dispersion patterns logic to the logic implemented in the model INCURSION embedded in ALWSIM.

Check the design, logic and code in the following areas to verify that the system will perform as specified:

- bullets can be loaded and the number of rounds is properly displayed
- gun can be selected and armed (master arm)
- gun correctly positioned (AUTO/CLOSED/LOAD/DEPLOY)
- gun can be targeted within correct azimuth and elevation limits
- gun can be fired - trigger 1st and 2nd detent operation
- rounds remaining decreases properly
- bullets follow proper trajectory and impact about targeted point
- compute all data required by Environment segment for DIS PDUs

NEEDED: M-230E1 30mm Gun capabilities description.

2.75" FFAR MK-66

Represent trajectory of each powered projectile using a flyout table. Aerodynamic modeling not required. Generate dispersion pattern centered on projectile trajectory.

Compare flyout and dispersion patterns logic to the logic implemented in the model INDIRECT FIRE EFFECTS embedded in ALWSIM.

Check the design, logic and code in the following areas to verify that the system will perform as specified:

- rockets can be loaded and the number of rounds is properly displayed
- rockets can be selected and armed (master arm)
- rockets can be properly targeted
- rockets can be fired - trigger 1st and 2nd detent operation
- number remaining decreases properly
- rockets follow proper trajectory and impact about targeted point
- compute all data required by Environment segment for DIS PDUs

NEEDED: 2.75" FFAR MK-66 capabilities description.

AGM-114A SEMI-ACTIVE LASER HELLFIRE (SAL HF)

Represent trajectory of each powered missile using a flyout table. Aerodynamic modeling not required. Model acquisition probability as a function of

- range to target
- laser range to target
- reflected energy
- background

Use PHI model in ALWSIM for laser target acquisition probability comparison.

Use ALWSIM flyout logic for comparison to HELLFIRE flyout.

Check the design, logic and code in the following areas to verify that the system will perform as specified:

- missiles can be loaded and the number of rounds is properly displayed
- missiles can be selected in desired sequence and armed (master arm)
- missiles can be properly targeted to obtain "SHOOT" cue
  - target must be within kinematic range of missile
  - target must be designated with correct code
  - can be designated autonomously or remotely
  - seeker must acquire (function of range/weather, CLOS)
  - designated target within seeker azimuth and elevation FOV limits
  - aircraft launch constraints must be met
  - indirect fire and lock-on-after-launch modes
- missiles can be fired - trigger 1st and 2nd detent operation
- missiles fire in selected order
- number remaining, and their location, properly displayed
- missiles follow proper trajectory and impact target
- compute all data required by Environment segment for DIS PDUs

NEEDED: AGM-114A LASER HELLFIRE capabilities description.

AGM-114F RF HELLFIRE

Represent trajectory of each powered missile using a flyout table. Aerodynamic modeling not required. Model acquisition probability as a function of range to target, radar range to target, and target radar cross section.

Use ACQUIRE model in ALWSIM for radar acquisition, tracking performance, and probability comparison.

Use ALWSIM flyout logic for comparison to HELLFIRE flyout.

Check the design, logic and code in the following areas to verify that the system will perform as specified:

- missiles can be loaded and the number of rounds is properly displayed
- missiles can be selected in desired sequence and armed (master arm)
- missiles can be properly targeted to obtain "SHOOT" cue
  - target must be within kinematic range of missile
  - target must be illuminated with correct code
  - can be designated autonomously or remotely
  - seeker must acquire (function of range/weather, CLOS)

- designated target within seeker azimuth and elevation FOV limits
- aircraft launch constraints must be met
- indirect fire and lock-on-after-launch modes

- missiles can be fired - trigger 1st and 2nd detent operation
- missiles fire in selected order
- number remaining, and their location, properly displayed
- missiles follow proper trajectory and impact target
- compute all data required by Environment segment for DIS PDUs

NEEDED: AGM-114F RF HELLFIRE capabilities description.

<u>AGM-114K RF HELLFIRE II</u>

Represent trajectory of each powered missile using a flyout table. Aerodynamic modeling not required. Model acquisition probability as a function of range to target, radar range to target, and target radar cross section.

Use ACQUIRE model in ALWSIM for radar acquisition, tracking performance, and probability comparison.

Use ALWSIM flyout logic for comparison to HELLFIRE flyout.

Check the design, logic and code in the following areas to verify that the system will perform as specified:

- missiles can be loaded and the number of rounds is properly displayed
- missiles can be selected in desired sequence and armed (master arm)
- missiles can be properly targeted to obtain "SHOOT" cue
    - target must be within kinematic range of missile
    - target must be illuminated with correct code
    - can be designated autonomously or remotely
    - seeker must acquire (function of range/weather, CLOS)
    - designated target within seeker azimuth and elevation FOV limits
    - aircraft launch constraints must be met
    - indirect fire and lock-on-after-launch modes
- missiles can be fired - trigger 1st and 2nd detent operation
- missiles fire in selected order
- number remaining, and their location, properly displayed
- missiles follow proper trajectory and impact target
- compute all data required by Environment segment for DIS PDUs

NEEDED: AGM-114K RF HELLFIRE II capabilities description.

Table 6.3.3.2.3 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				√

Table 6.3.3.2.3 Logic and Code Verification Activities for AH-64D Weapons

6.3.3.2.4 AH-64D Sensors

The Night Vision and Electronic Sensors Directorate of AMSAA has been involved with the verification and validation of sensor displays in the past and should be involved with our current effort. Previous sensor display evaluation at AMSAA have focused on the results of an initiative on the ACQSIM Simulation for Target Acquisition.

<u>AN/ASQ-11 FLIR PNVS</u>

The Visual System Module (VSM) computer image generation (CIG) system (an ESIG-2000) will dedicate one of its channels to producing the FLIR image. The task is to validate that the ESIG-2000 properly generates IR images of the terrain and moving models.

SPARTA does not have any means of generating IR imagery from the terrain and moving model data bases. We could use FLIR90 to generate minimum resolvable contrast (MRC) and minimum resolvable temperature differences (MRTDs) of selected targets at selected ranges, at selected aspect angles against selected backgrounds at selected times of day and season. We would then have to extract the digital image from the ESIG-2000 under the same selected conditions (I don't know if that's possible). The extracted image could then be analyzed to determine if the ESIG-2000 correctly transformed the terrain and moving model 3D representations into 2D IR images.

<u>AN/AAQ-170 TADS</u>

The following assumptions were made by Boeing for the Comanche EOTADS and are assumed for the Longbow as well. See Boeing's section of the PMR No. 2 briefing.

- target detection and classification shall be probabilistically determined as a
    function of range to target, visibility, and adaptability parameters
    (see Faxed material)
    -- frequency
    -- etc.
- target prioritization shall be a function of sensor ID, target type, and range
- laser range error will be a function of the adaptability parameter

Table 6.3.3.2.4 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.3.2.4 Logic and Code Verification Activities for AH-64D Sensors

6.3.3.2.5 AH-64D ASE

Radar Warning APR-39 (V)1 (V)2
APR-48

Simulate RF emitter detection and identification performed by the Radar Warning Receiver (RWR).

Provide receiver status, RF indications, and alerts to the FSM.

RF indications include detection range and parameter limit detection (RF, PRF, and PW).

The intent is to characterize the performance of the RWR by defining the following adaptability parameters:
- frequency
- PRF (pulse repetition frequency)
- PW (pulse width)
- FOV (field of FOV)
- detection range

- direction finding

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the radar warning adaptability parameters; EID file; threat emitter type, location, power, mode, and beam characteristics; and ownship location and orientation:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensors
- identification in accordance with EID file and emitter beam parameters
- maximum detection range and range estimate from ID, EID file and detected power
- detection/no detection from maximum range and threat and ownship locations
- coarse radar site list for radar warning receiver and radar jammer operation
- emitter mode (search, acquisition, track, or missile activity) from EID file and emitter beam characteristics and activity
- emitter relative bearing from AOA information and ownship heading
- emitter priority based on priority in EID file, detecting equipment and range
- emitter location based on range and bearing
- emitter location based on triangulation processing by multiple team members
- radar warning indications (up to 8 visual effects and up to 5 visual effects), prioritized target list and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the radar warning adaptability parameters

NEEDED: APR-39 (V)1 (V)2, APR-48 capabilities description.

Radar Jammer ALQ-136 (V)1/5

Simulate the matching of detected RF emitter to jamming signal.

Identify detection range and parameter limits.

Provide radar jammer status to the FSM.

Provide the interface to the DIS network protocols for the transmitted RF signal(s).

The intent is to characterize the performance of the jammer by defining the following adaptability parameters:

- frequency
- power
- technique
- FOV (field of FOV)
- jam range

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the radar jammer adaptability parameters; EID file; course radar site list; and ownship location and orientation:

- equipment functional status from electric power indications, ECM enable status and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or antennas
- emitter detected if on course radar site list generated by radar warning receiver

- emitter prioritized in accordance with EID file and range between emitter site location and ownship location
- AOA evaluations using ownship angular position values, actual earth axis azimuth and elevation to the emitter, and EID file error indications
- radar jamming parameters using results of the AOA evaluations, the RF emitter's beam parameters and the EID file jamming indications
- RF jamming characteristics required to effectively simulate the jamming of the selected emitters (up to 10) and other interface parameters computed and passed
- jamming characteristics can be modified within the limits of the radar jammer adaptability parameters

NEEDED: ALQ-136 (V)1/5 capabilities description.

Laser Warning AVR-2 (V) TBD

Simulate laser emitter detection and identification performed by the Laser Warning Receiver (LWR).

Provide receiver status, laser indications, and alerts to the FSM.

The intent is to characterize the performance of the LWR by defining the following adaptability parameters:

- frequency
- PRF (pulse repetition frequency)
- PW (pulse width)
- FOV (field of FOV)
- detection range

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the laser warning adaptability parameters; laser ID file; laser type, location, power, code, and beam characteristics; and ownship location and orientation:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensors
- identification in accordance with laser ID file and laser beam parameters
- maximum detection range and range estimate from ID, laser ID file and detected power
- detection/no detection from maximum range and laser and ownship locations
- laser code from laser ID file and laser beam characteristics
- laser relative bearing from AOA information and ownship heading
- laser priority based on priority in laser ID file and range
- emitter location based on range and bearing
- emitter location based on triangulation processing by multiple team members
- laser warning indications (up to TBD visual effects and up to TBD visual effects), prioritized target list and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the IR warning adaptability parameters

NEEDED: AVR-2 (V) capabilities description.

<u>IR Jammer</u> ALQ-144 (V)1/3

Simulate IR jamming characteristics: power, frequency, field of view.

Provide IR jammer status to the FSM.

Provide the interface to the DIS network protocols.

The intent is to characterize the performance of the IR jammer by defining the following adaptability parameters:

- frequency
- power
- technique

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the IR jammer adaptability parameters; IR jammer characteristics; location of IR seeker; and ownship location:

- equipment functional status from electric power indications, ECM enable status and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or IR element
- IR jamming parameters for simulation of the cooldown and warmup cycling technique
- IR jamming characteristics and other interface parameters computed and passed
- jamming characteristics can be modified within the limits of the IR jammer adaptability parameters

NEEDED: ALQ-144 (V)1/3 capabilities description.

<u>Chaff M-I</u> M-130 Dispenser

Simulate chaff loading.

Simulate chaff release.

Simulate chaff system status and inventory.

Simulation of dispensed chaff characteristics to the extent to provide interface to the DIS network protocols.

Check the design, code and logic to verify that the following parameters will be properly computed in accordance with the chaff adaptability parameters; pilot switch selection and actions; and ownship location:

- equipment functional status from electric power indications, chaff inventory, chaff selection and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or dispenser
- chaff dispensed upon command when manual mode selected
- chaff dispensed in accordance with system characteristics or adaptability parameters when automatic mode selected
- chaff inventory decremented by the number of bundles dispensed
- release indication and other interface parameters computed and passed
- delivery system characteristics and/or chaff characteristics can be modified within the limits of the chaff adaptability parameters

NEEDED: Chaff M-I capabilities description.

Table 6.3.3.2.5 shows the logic and code verification activities that are to be performed during each development phase for this component.

Activity: / Phase:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				√

Table 6.3.3.2.5 Logic and Code Verification Activities for AH-64D ASE

6.3.3.2.6 AH-64D Flight Dynamics

From the System/Segment Specification:

"The Flight Dynamics segment for the AH-64D will be adapted from the aerodynamic model that exists in the AH-64D EDS and will be in the FORTRAN programming language, assuming modifications will be less than 40%. The Flight Dynamics segment shall provide for a realistic simulation of the flight characteristics of the simulated aircraft. The simulation shall include portions of the flight envelope which reflect combat operations such as: cruise, ascent, descent, hover, low-level (i.e., within ground effect) flight, approach and landing within a refueling/rearmament zone and subsequent takeoff from that zone. The simulation shall reproduce fidelity of flight operations to a level which will closely resemble that of the selected aircraft and which will not cause either distraction of the pilot or an increase or decrease in the performance of the air vehicle to an extent that would affect combat effectiveness or associated test results. The simulation shall include forces and moments, equations of motion, weight and balance, envelope violation, aerodynamics and ground handling. The flight dynamics simulation shall also include the ability to set and/or adjust certain device parameters to include maximum speed, fuel load time, maximum pitch, roll and yaw rates, turning radius, number of blades and no tail rotor effect on performance, failures from combat and crash damage, gross weight limitations, external fuel tanks, weapons selection, wing stores, internal stores configuration and load time for ammunition."

Adaptability parameters are being reviewed for practicality of control. The final selection of adaptability parameters will depend on the completed TSA/SFA.

Check the design, logic and code in the following areas to verify that the segment will perform as specified:

- rotor aerodynamics computation of the forces, moments and torques generated by the main rotor and fantail during all modes of operation
- airframe aerodynamics computation of the aerodynamics forces and moments generated by the airframe (i.e., fuselage, vertical tail, horizontal stabilizer, landing gear and doors)
- ground handling computation of the vertical force generated by the interaction of the aircraft landing gear with the ground
- mass properties computation of aircraft gross weight, center of gravity position, and moments and product of inertia
- total forces and moments computation of the total forces and moments acting on the aircraft in the body axis coordinate system
- envelope violation monitoring capability of critical flight parameters to determine if the structural capabilities of the aircraft have been exceeded resulting in a crash condition
- equations of motion computation of aircraft state, which include linear and angular positions, velocities, and accelerations in both the body and earth axis coordinate systems
- ability to set and/or adjust the flight dynamics segment adaptability parameters
- simulation of the effect of changes in the physical configuration/position of the aircraft fuselage components and degraded flight performance due to battle damage

Table 6.3.3.2.6 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.3.2.6 Logic and Code Verification Activities for AH-64D Flight Dynamics

6.3.3.2.7 AH-64D Propulsion

Information on the approach and design criteria for the AH-64D propulsion segment is not yet available. Although MDHC has a high fidelity model of the GE-701 engine, it is anticipated that this model will be adapted to model the same level of fidelity will be modeled as for the RAH-66.

T701C Engine Simulation
- Simulate rotor torque/speed function
    - main rotor speed
    - tail rotor speed
    - transmission oil temperature and pressure
- Simulate gas generator function
    - gas generator speed
    - power turbine speed
    - engine oil temperature and pressure
    - engine torque
- Simulate engine fuel function
- - fuel rates
- - turbine gas temperature

Approach to simulation:

Engine oil temperature and pressure are initialized and held constant unless battle damage has occurred.

Transmission oil temperature and pressure are initialized and held constant unless battle damage has occurred.

Power turbine speed is initialized and held constant unless battle damaged.

Check the design, logic and code in the following areas to verify that the segment will simulate the engines and transmission of the AH-64D as specified:
- rotor torque/speed as a function of the torque requirements generated in the flight dynamics section
- engine fuel burn rate as a function of torque output and gas turbine speed
- gas generator core speed modulation to maintain the 100% rotor speed demand
- ability to set and/or adjust the propulsion segment adaptability parameters
- simulation of the reactions to, and indications of, sustained battle damage

Table 6.3.3.2.7 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.3.2.7 Logic and Code Verification Activities for AH-64D Propulsion

6.3.3.2.8 AH-64D Physical Cues

"The Physical Cues segment shall simulate the environmental sounds, navigation system tones and threat audio tones for the AH-64D aircraft. The simulated sounds shall include engines, rotors, small arms impacts, ownship weapons firings and weapon detonation,. Simulated tones shall include aircraft warning system synthetically generated tones, radar induced tones and navigation systems tones. The spectral content and loudness levels of these sounds and tones shall be dynamically controlled to represent realistic responses to simulated events. There shall be no motion system or motion cues provided."

SPARTA shall check the design, logic, and code to verify that these function are implemented as specified.

Table 6.3.3.2.8 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.3.2.8 Logic and Code Verification Activities for AH-64D Physical Cues

6.3.3.2.9 AH-64D TNE

The Tactical and Natural Environment segment will receive special attention for, through it, the ARWA SS interfaces with the rest of the Multiple Simulator Environment (MSE). And since these data then flow to and from the other segments of the AH-64D Simulator System Module, in order to interact with/stimulate their models, the proper implementation and functioning of the TNE segment is crucial to the proper functioning of the entire AH-64D Simulator System Module. Verification will require a check of the design, logic and code in the following areas to verify that the segment will operate as specified:

<u>Network Interface Function</u>

- Provide for information updates conforming to the Distributed Interactive Simulation (DIS) standard.
- Provide this information to the ongoing simulation of the ownship environment as appropriate.
- Perform all necessary conversions to conform to ARWA internal data formats and units.

<u>Atmosphere Function</u>

- Provide for simulation of a medium fidelity atmosphere.
- Simulate air mass, global winds, and turbulence.
- Provide global definitions of temperature and pressure.

<u>External Entities Function</u>

- Simulate the position and attitude of other vehicles between updates from the multi-simulator environment (MSE).
- Upon receiving such updates, the TNE segment shall seamlessly inject the new data into the vehicle simulation.

<u>Ownship Weapon Damage Function</u>

- Provide to the MSE information regarding ownship weapon path, detonation and ordinance.
- The information shall be passed through to the external simulation through the Network Interface function.

<u>Threat Weapon Dynamics Function</u>

- Simulate the flight of threat weapons between updates from the MSE.

<u>Threat Platform Dynamics Function</u>

- Simulate the flight of threat platforms between updates from the MSE.

Table 6.3.3.2.9 shows the logic and code verification activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Logic Verification				
Documentation Review	√	√	√	
Design Walk-through		√	√	
Flow Diagram Review		√		
Algorithm Checks		√		
Logic Representation			√	
Code Verification				
Code Walk-through			√	
Peer Review			√	
Units Check			√	
Logic Representation			√	
Sensitivity Analysis				√
Statistical Test				

Table 6.3.3.2.9 Logic and Code Verification Activities for AH-64D TNE

7.0 VALIDATION AGENDA

The structure and code validation procedures, products, and data requirements described in sections 7.1 and 7.2 represent the complete set of activities that would be performed for V&V Intensity Level 1. The specific structure and code and model validation activities to be performed for each ARWA SS component are defined in Section 7.3.

Prior to CDR, the V&V team will identify and collect or generate the necessary data, scenarios, etc. to support the validation tasks. Agencies such as BRL and AMSAA will be data sources for several areas of investigation. Some typical real world data sources that SPARTA intends to use are:

• A Compendium of Close Combat Tactical Trainer Data Structures, Algorithms, and Generic System Mappings

- CASTFOREM. This is a combat simulation that models the combat process more rigorously than the force-on-force model GROUNDWARS. CASTFOREM incorporates the effects of C3I, nuclear-bilogical-chemical weapons, suppression, laser weapons, and multi-target scenarios on the target acquisition and engagement process.

- GROUNDWARS. This force-on-force combat simulation uses Night Vision Laboratory (NVL) models to characterize the target acquisition process.

- LORAM. The Low Observable Radar Model (LORAM) is a one-on-one radar perfromance model designed to predict the detectability of low observable targets by battlefield surveillance radars.

• TBD

7.1 STRUCTURE VALIDATION

Structural validation focuses upon the internal portion of the ARWA SS which includes examination of the assumptions and review of the algorithms and architecture in the context of the intended use. Structural validation will examine the sensitivity of the simulator modules to proper data input items, determine whether there is a balance of resolution in the algorithms / modules, determine to what degree the simulator's modules represent their counterparts in the "real-world", and determine if the simulator is complete and all the necessary functions are modeled.

The two areas that the V&V team will address in the validation process are 1) identification of the "real world" being modeled in each software segment, and 2) identification of the key modeling characteristics and output parameters in each software segment that are to be used in the comparisons. Validation involves the comparison of the simulator behavior and results to data obtained from another credible domain that is either believed to be the "real world", or has been proven to closely approximate the "real world", or is from a source that is recognized as expert on the relevant characteristics of the "real world". The standard of quality that the simulator is expected to meet is a part of this identification process. This is a critical part of the validation process because the "real world" is frequently not a tangible entity, particularly in the realm of combat modeling. For ARWA SS program, the primary validation reference will be the government furnished

Task and Skills and Selected Fidelity Analyses. The V&V team references will also be applied as consistency checks. In addition, the V&V team will identify the key modeling characteristics and output parameters for each of the modules being investigated during this phase of the program.

After these validation tasks have been performed, the V&V team will integrate the results from them and will prepare a statement of credibility that will state the capabilities and limitations of the models in each software segment.

The specific methods that the V&V team will employ and document in order to validate the ARWA SS modules are described in the following paragraphs.

7.1.1 Documentation and Reviews

The ARWA V&V team will review the ARWA SS specifications and design documents prior to key program events to include PDR and CDR.

Upon the completion of validation tasks for each module, a report will be generated. This report will include a description of the decomposition and the level of depth achieved. This section will contain the evaluation criteria which is a description of the "real world" to include a description of the data that was chosen for comparison and/or a brief background of SMEs used. Structural validation test descriptions and results will be noted plus any differences compared to the original plan of effort. The methods used to perform the structural validation will be described. The same detailed information will be provided for output validation activities performed. Finally in this section, unresolved issues will be noted.

7.1.1.1 PDR Through CDR Phase

Data Sources

Table 7.1.1.1-1 describes the data sources that can be used from PDR through CDR.

Title	Description	Format Guide	Source	Associated Procedure
Software Design Documents (Preliminary)	Specifies the preliminary design of the CSCI.	TBD (DI-MCCR-80012A)	Developer	1,3
Interface Design Documents (Preliminary)	Specifies the preliminary design of one or more interfaces between CSCI(s).	TBD (DI-MCCR-80027A)	Developer	1,3
Software Design Documents (Detailed)	Specifies the detailed design of the CSCI to the CSU level.	TBD (DI-MCCR-80012A)	Developer	1,3
Interface Design Documents (Detailed)	Specifies the detailed design of one or more interfaces between CSCI(s) or other configuration or critical items.	TBD (DI-MCCR-80027A)	Developer	1,3
Software Test Plan	Defines the software test environment resources required, the schedule of test activities, and the individual test to be performed.	TBD (DI-MCCR-80014A)	Developer	2,3
Developers Contract SOW, Format Guide and tailored DIDs	Document Format and Content Requirements	N/A	Gov't	1,2,3

Table 7.1.1.1-1 PDR Through CDR Phase Validation Data Sources

Procedures

The following paragraphs describe the procedures that can be used from PDR through CDR.

1. Review Detailed Software and Interface Design Documents against the Preliminary Software and Interface Design Documents as well as the Software and Interface Requirements Specification. The goal as before is to assure that all requirements

have been addressed and that no software or interface design feature exists which can not be matched to a corresponding requirement. Enter this traceability information in the V&V documentation to support further traceability efforts at the coding and unit test level. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

- Requirements which are not addressed,
- Software and Interface design features which do not support a higher-level requirement,
- Format and content discrepancies.

2. Review Software Test Plan against the Software and Interface Requirements Specification. The software Test Plan defines the formal quaiification tests for the CSCI, the software test environment resources required, the schedule of activities, and the individual test to be performed. The goal of this review is on the identification of test which will provide objective evidence that the CSCI meets its requirements. Enter this traceability information in the V&V documentation to support further traceability activities at the coding and unit test level. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

   - Requirements for which no test is identified,
   - Tests identified, but for which a requirement cannot be identified,
   - Level and type of testing to be performed to satisfy each requirement,
   - Format and content discrepancies.

3. Support Reviews and Audits by :

   - Providing briefing books containing summary status information for each critical CSCI. Summary information will include software size estimates, schedule (planned versus actual), and action items to be addressed during the meeting,
   - Participating in the review as directed by the Prime.

Products

Table 7.1.1.1-2 describes the validation products generated from PDR through CDR.

Title	Description	Format Guide	Frequency
V&V Plan	Report on the completeness of the Preliminary Software Design Documents (one per module)	TBD	Once per module
V&V Plan	Report on the completeness of the Preliminary Interface Design Documents (one per module)	TBD	Once per module
V&V Plan	Report on the completeness of the Detailed Software Design Documents (one per module)	TBD	Once per module
V&V Plan	Report on the completeness of the Detailed Interface Design Documents (one per module)	TBD	Once per module
V&V Plan	Report on the completeness of the Software Test Plans (one per module)	TBD	Once per module
V&V Plan	Briefing materials reflecting the status of each modules	TBD	Once per module

Table 7.1.1.1-2 PDR Through CDR Phase Validation Products

7.1.1.2 Post CDR through Code and Unit Test (CUT) Phase

Data Sources

Table 7.1.1.2-1 describes the data sources that can be used after CDR and during the code and unit test phases.

Title	Description	Format Guide	Source	Associated Procedure
Software Requirements Specification	Specifies the engineering and qualification requirements of a CSCI.	TBD (DI-MCCR-800-25A)	Developer	1,2,4,6
Interface Requirements Specification	Specifies the requirements for one or more interfaces between one or more CSCIs.	TBD (DI-MCCR-800-26A)	Developer	1,2,4,6
Software Design Documents (Detailed)	Specifies the detailed design of the CSCI to the CSU level.	TBD (DI-MCCR-80012A)	Developer	1,2,4,6
Interface Design Documents (Detailed)	Specifies the detailed design of one or more interfaces between CSCI(s)	TBD (DI-MCCR-80027A)	Developer	1,2,4,6
Source Code and Software Development Files (SDF)	From the Developmental Configuration, these represent the implementation of the design (the code) and the rationale supporting developer implementation decisions (the SDF)	TBD (Data Accession List)	Developer	2, 6
Software Test Plan	Defines the software test environment resources required, the schedule of activities, and the individual test to be performed.	TBD (DI-MCCR-80014A)	Developer,	3,5,6
Software Test Descriptions	Defines the test cases and procedures needed to perform formal qualification testing of a CSCI in accordance with the STP.	TBD)DI-MCCR-80015A)	Developer	3,5,6
Software Test Reports	Serves as a record of the formal qualification testing performed on a CSCI.	TBD (DI-MCCR-80017A)	Developer, Gov't	5,6
Developers Contract SOW, Format Guide and tailored DIDs	Document Format and Content Requirements	N/A	Gov't	1,2,3,4,5, 6

Table 7.1.1.2-1 Post-CDR Phase Validation Data Sources

Procedures

The following paragraphs describes the data sources that can be used after CDR and during the code and unit test phases.

1. Review Detailed Software and Interface Design Documents during Coding and CSU Testing and CSC Integration and Testing phases. This review compares the SDD and IDD products, while they are evolving in the contractor controlled Developmental Configuration, against the Software and Interface Requirements Specification to assure that all requirements continue to be addressed and that no software or interface design feature exists which can not be matched to a corresponding requirement. Enter this traceability information in the V&V documentation to support further traceability efforts as these SDD and IDD are updated. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

   - Requirements which are not addressed by design,
   - Software and Interface design features which do not support a higher-level requirement,
   - Format and content discrepancies based on the contractor specified format.

2. Review Source Code during Coding and CSU Testing and CSC Integration and Testing phases against the Detailed Software and Interface Design Documents, the Software and Interface Requirements Specification. The goal as before is to assure that all requirements have been addressed and that no software or interface design feature is implemented in the code which can not be matched to a corresponding requirement. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

   - Requirements which are not addressed by code,
   - Software and Interface code features which do not support a requirement, or trace directly to design,
   - Non-adherence to the contractor's software standards and procedures format and content requirements.

3. Review Software Test Descriptions against the Software and Interface Requirements Specification and against the Software Test Plan. The software test descriptions begin by defining test cases prior to CDR and continue to be further refined by defining the test procedures. The goal of this review is similar to the preceding reviews, however we are focusing on the identification of the specific test cases and detailed procedures which will provide complete and objective evidence that the CSCI meets its requirements. Enter this traceability information in the V&V documentation to support further traceability activities. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

   - Requirements for which no test is identified (our Soundness characteristic examines the adequacy of the tests),
   - Tests identified, but for which a requirement cannot be identified,
   - Format and content discrepancies.

4. Review Detailed Software and Interface Design Documents. This review compares the SDD and IDD products against the Software and Interface Requirements Specification to assure that all requirements have been addressed and that no

software or interface design feature exists which can not be matched to a corresponding requirement. Enter this traceability information in the V&V documentation. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

- Specifications which are not addressed,
- Software and Interface design features which do not support a higher-level requirement,
- Format and content discrepancies.

5. Review Software Test Reports against the Software and Interface Requirements Specification and against the Software Test Plan and Software Test Descriptions. The STR is reviewed for test completeness, insuring that all planned tests and procedures are documented with results. The goal of this review is to determine that all tests were exercised or explanations are present and that the results provided sufficient objective evidence that the CSCI meets its requirements. Enter this traceability information in the V&V documentation. Enter any discrepancies into the discrepancy and problem tracking data base maintained by the CCB. Identify the following in the V&V Plan:

    - Requirements for which no test is reported,
    - Tests identified, but for which a requirement cannot be identified,
    - Test results which do not support the objectives of the STP and STDs,
    - Tests which did not meet satisfactory completion, or achieve conditions defined in the STD under which the test result is inconclusive,
    - Format and content discrepancies.

6. Support Reviews and Audits by :

    - Providing briefing books containing summary status information for each critical CSCI. Summary information will include software size estimates, schedule (planned versus actual), and action items to be addressed during the meeting,
    - Participating in the review as directed by the Prime.

Products

Table 7.1.1.2-2 describes the validation products generated after CDR and the code and unit test phase.

Title	Description	V&V Format Guide	Frequency
V&V Plan	Report on the completeness of the Detailed Software Design Documents during Coding, CSU Testing, CSC Integration and Testing.	TBD	Once for each critical CSCI.
V&V Plan	Report on the completeness of the Detailed Interface Design Documents during Coding, CSU Testing, CSC Integration and Testing.	TBD	Once for each critical CSCI.
Title	Description	V&V Format Guide	Frequency
V&V Plan	Report on the completeness of the Source Code during Coding, CSU Testing, CSC Integration and Testing phases.	TBD	Once for each critical CSCI.
V&V Plan	Report on the completeness of the Software Test Descriptions prior to Test Readiness Review.	TBD	Once for each critical CSCI.
V&V Plan	Report on the completeness of the Detailed Software Design Documents.	TBD	Once for each critical CSCI.
V&V Plan	Report on the completeness of the Detailed Interface Design Documents.	TBD	Once for each critical CSCI.
V&V Plan	Report on the completeness of the Software Test Reports.	TBD	Once for each critical CSCI.
V&V Plan	Briefing book reflecting the status of each critical CSCI undergoing review or audit.	TBD	Once for each critical CSCI.

Table 7.1.1.2-2 Post-CDR Phase Validation Products

7.1.1.3 System Integration and Test

The ARWA V&V team will review the results of the individual Segment Code and Unit Test evaluations in preparation for the system integration and test. The team will identify any perceived possible problem areas to be carefully monitored during the integration process. These possible problem areas will be documented prior to integration and the unique test procedures may be imposed to assist in the validation of the segments involved in the concerned areas.

The V&V team will support any and all reviews associated with the preparation for system integration and test as well as concurrent to the integration process as required by the Prime.

7.1.2 Real World Comparisons

The ARWA V&V team will compare the code, documentation, input data, and results from reference "criteria" models with models from the ARWA SS. Thus, for this approach to be meaningful, the reference models must be of the same or higher fidelity than used in the ARWA SS and must be accredited for use in a similar application.

The V&V team will compare the code, documentation, input data, and results from reference "criteria" models with models from the ARWA SS. Thus, for this approach to be meaningful, the reference models must be of the same or higher fidelity than used in the ARWA SS and must be accredited for use in a similar application.

To actually perform the comparisons, the V&V team will make up input data sets for both the ARWA SS and reference models, run the models, then compare the results. Where possible, the V&V team will obtain data sets for the reference models directly. In these cases, the V&V team will develop identical (or equivalent) input data sets for the ARWA SS models, have the models run, and compare the results. A judgment will then be made as to whether the results compare closely enough to deem the models validated. The V&V team will pre-establish tolerances, parameter by parameter, on which to base its judgment for the variables of interest.

7.1.3 Software Architecture Assessment

This "piece-wise validation" approach provides a logical means of performing piece-wise test design, testing, and analysis of large, complex simulations like the ARWA SS. The V&V team will divide the ARWA SS into its software segments and these, in turn, will be divided into their functional elements. The V&V team will then bring in subject-matter experts, as required to supplement its V&V team, to examine the documentation, code, and output and determine the degree of fidelity that is represented in each functional area.

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7.1.4 Face Validation (SME Review)

Face validation relies on the opinion of subject-matter experts as to whether the behavior of each software segment, or its component, is "reasonable." This, by definition, provides a subjective assessment of the validity of the models and serves as a point of departure for a more comprehensive validation. The V&V team will assemble this team and participate in, and guide, its activities.

The V&V personnel and other competent, objective reviewers who are independent of the model developer will conduct a detailed verification and validation review. This may overlap with the functional decomposition phase in that some of the same people may be involved. In the independent reviews, the scope of activities is somewhat greater, however, in that the reviewers will examine the verification and validation methods performed by the model developer, in addition to performing a detailed verification and validation of the models.

The V&V personnel and other competent, objective reviewers who are independent of the model developer will conduct a detailed verification and validation review. This may overlap with the functional decomposition phase in that some of the same people may be involved. In the independent reviews, the scope of activities is somewhat greater, however, in that the reviewers will examine the verification and validation methods performed by the model developer, in addition to performing a detailed verification and validation of the models.

Face validation relies on the opinion of subject-matter experts as to whether the behavior of each software segment, or its component, is "reasonable." This, by definition, provides a subjective assessment of the validity of the models and serves as a point of departure for a more comprehensive validation. The V&V team will assemble this team and participate in, and guide, its activities.

7.2 OUTPUT VALIDATION

7.2.1 Evaluate T&E Criteria

The ARWA V&V team will review and submit for revision or update comments or concerns on the methods, procedures, and quantitative bounds to be implemented in the

Testing and Evaluation of the Segment and System results. The team will base all comments and concerns upon the requirements specified in the documentation maintained by the CCB (SSS, SRS, IRS, STP, and STD). Additionally, the team will utilize expert sources to obtain concerns/comments on the possible "feel" which should be expected. All V&V team information will be documented and presented to the Prime and subcontractors.

7.2.2 Data Collection

The ARWA V&V team will review and submit for revision/update comments/concerns on the data collection methods and procedures as well as the exact data items required for validation of segments. The team will base all comments and concerns upon the requirements specified in the documentation maintained by the CCB (SSS, SRS, IRS, STP, and STD). Additionally, the team will utilize expert sources to obtain concerns/comments on the possible "feel" which should be expected. The V&V team should also have an opportunity to interview the personnel selected to pilot the simulator during the system integration tests in order to obtain their prioritization of sensory cues. All V&V team information will be documented and presented to the Prime and subcontractors.

7.2.3 Scenario Identification

The V&V team will review and submit for revision/update comments/concerns on the planned scenarios used to validate the segments and the system. The scenarios will be compared to the requirements which must be tested to insure that nominal and stressing conditions are tested against each requirement. The number of events and complexity of mission will be evaluated to insure a limited set of scenarios (runs) will be required to validate the segment and/or system. All V&V team information will be documented and presented to the Prime and subcontractors.

7.2.4 Models

Prior to CDR, the V&V team will identify and collect or generate the necessary models to support the validation tasks. This collection of models will range from the module / algorithm level to the system level and will also cover the range of resolution from high to low. Some of these models will be used to generate the data base inputs.

The V&V team will obtain models, where available, of the same or higher fidelity than used in the ARWA SS which are accredited for use in a similar application. These will be used where need is indicated as consistency checks on the government Task, Skills and selected Fidelity Analyses. A partial list of potential models for consideration in this task is shown in Tables 7.2.4-1A, -1B, and -1C. This list of models will be expanded during the

execution of this task. The Tactical Environment Simulator (TES) and ALWSIM are in-house SPARTA capabilities and are discussed in detail below.

TABLE 7.2.4-1A CANDIDATE MODEL LIST

NAME	*TYPE*
ALWSIM	System Level Simulation
HELMATES	System Level Engagement Simulation (Few on Few)
TES	Tactical Environment Simulator
EVADE	System Level Engagement Model
INCURSION	One on One System Level Engagement Simulation
TRAP	Weapon Model
P001A	Weapon Model
CNVEO Target Acquisition Model	Passive Target Acquisition Model
AIRADE	Radar Model
TRAM	Radar Model
DMEWS	RF Effects Model
MIVAC	Vulnerability Assessment Model
Manufacturer's Engineering Simulation	Flight Dynamics

TABLE 7.2.4-1B CANDIDATE MODEL LIST - AH-64D

AIRCRAFT	SUBSYSTEM	FUNCTION	MODEL IDENTIFIED
AH-64D			
	M-230E1 30 MM GUN		INCURSION
	2.75" FFAR MK-66		INDIRECT FIRE EFFECTS
	AGM-114A LASER HELLFIRE		PHI, ALWSIM
	AGM-114F RF HELLFIRE		ALWSIM
	AGM-114K RF HELLFIRE II		ALWSIM
	AN/AAQ-11 FLIR PNVS		FLIR 90
	AN/ASQ-170 TADS		ALWSIM
		FLIR	ALWSIM
		DTV	ALWSIM
		DVO	ALWSIM
		LRF/D	no model
		LST/IAT	no model
	IHADSS		no model
		HDU	no model
		SSU	no model
		DAP	no model
		SEU	no model
		DEU	no model
	FCR		ACQUIRE

TABLE 7.2.4-1C CANDIDATE MODEL LIST - RAH-66

AIRCRAFT	SUBSYSTEM	FUNCTION	MODEL IDENTIFIED
RAH-66			
	VULCAN II 20 MM GUN		INCURSION
	HYDRA 70		no model
	2.75" FFAR MK-66		INDIRECT FIRE EFFECTS
	AGM-114A LASER HELLFIRE		PHI, ALWSIM
	ATAS		ALWSIM
	NVPS		(FLIR 90)
	EOTADS		ALWSIM
		FLIR	ALWSIM
		DTV	ALWSIM
		DVO	ALWSIM
		LRF/D	no model
		LST/IAT	no model
	FCR	TBD	ACQUIRE

7.2.5 Test and Evaluation

Test and Evaluation tasks take place primarily after CDR and continue through the end of the program. These tasks are applied to the simulator and they define how well the simulator results compare with the perceived "real-world". They also determine whether the simulator output is what is expected given the input / scenario. The test and evaluation tasks will employ many of the same methods discussed in Section 6.3. During this stage of testing, some of these methods are expanded to include module output in the comparison to the "real world" standards in the evaluation whereas during structural validation testing, the module output was not necessarily considered.

7.2.5.1 Stress Test and Sensitivity Analysis

The V&V team will conduct an analysis of the sensitivity and stress test results that are performed in the verification effort. These data will be reviewed by the V&V personnel and other subject-matter experts to check the validity of the model outputs for the conditions considered. Since the V&V team anticipates that it will have done a significant amount of testing during verification, there will be a complete set of data, covering all of the software segments, for the subject-matter experts to analyze. The reviewers will check for proper responses, given the input and changes in input.

Each validation task will address some portion of the questions identified as part of the validation plan. Each task will identify the method, tools, or techniques needed to perform the task, and identify the data values, algorithms, etc., to be compared. The resulting analysis will address:

1. The sensitivity of the model outputs to inputs and parameters and how this compares to the major influencing factors in the baseline "real world".
2. The assumptions made by model developers and their impact on model usage and whether or not these assumptions seriously affect the model's ability to portray, explain or predict.
3. The interfaces between model objects / processes and how well they parallel the established baseline interactions
4. The completeness and balance of the model logic across the model components.

<u>Model-Test-Model</u>

It is possible, if not probable, that the outputs of some of the models will not be consistent with data obtained from validated sources. When conducting the stress test and sensitivity analysis, the V&V team will look at the results of the comparison between model and "real-world" outputs to determine which models can realistically be modified to yield more credible results. Under these conditions the model should be modified or fine tuned to make its output consistent with "real world" data. Where modifications are required, the V&V team will document the inconsistencies thoroughly and will what modifications could yield a more valid model. The V&V team will transmit these results to the Army and the developer at as early a date as possible as candidate modifications to be implemented into the ARWA SS.

Similar to the structural validation tasks, each test and evaluation task will address some portion of the questions identified as part of the validation plan generated during phase I of this program. Each task will identify the method, tools, or techniques needed to perform the task, and identify the data values, algorithms, etc., to be compared. The resulting analysis will address:

1. The sensitivity of the model outputs to inputs and parameters and how this compares to the major influencing factors in the baseline "real world".
2. The assumptions made by model developers and their impact on model usage and whether or not these assumptions seriously affect the model's ability to portray, explain or predict.
3. The interfaces between model objects / processes and how well they parallel the established baseline interactions
4. The completeness and balance of the model logic across the model components.

After these validation tasks have been performed, SPARTA will integrate the results from them and will prepare a statement of credibility that will state the capabilities and limitations of the models in each software segment.

Tactical Environment Simulation Facility

The Tactical Environment Simulation (TES) facility is proposed for use as a simulator V&V tool for accomplishing validation of DIS interaction. This facility provides a realistic, real-time tactical environment for embedding ARWA developed elements for both verification and validation testing. The environment, available via DIS message streams, is comprised of opposing and friendly air and ground forces including aircraft, EW radars, command and control network, SAMs, and AAA. It has two manned pilot stations networked to it, and the entire facility, or elements of it, can be networked to manned, dome simulators or interact with the ModSAF SAFOR using the DIS protocol.

When so networked, TES would provide realistic stimuli to the manned simulators, which, in the ARWA SS V&V application, will permit the test and evaluation of device sensors, targeting systems, weapons, and ASE in a manner that will yield credible verification and validation results. A specific example is described following the TES hardware description. A block diagram of the TES architecture is presented in Figure 7.2.5.1-1. TES is hosted on a VAX-3540 in the TES facility but is hosted on a wide range of VAX's in other installations.

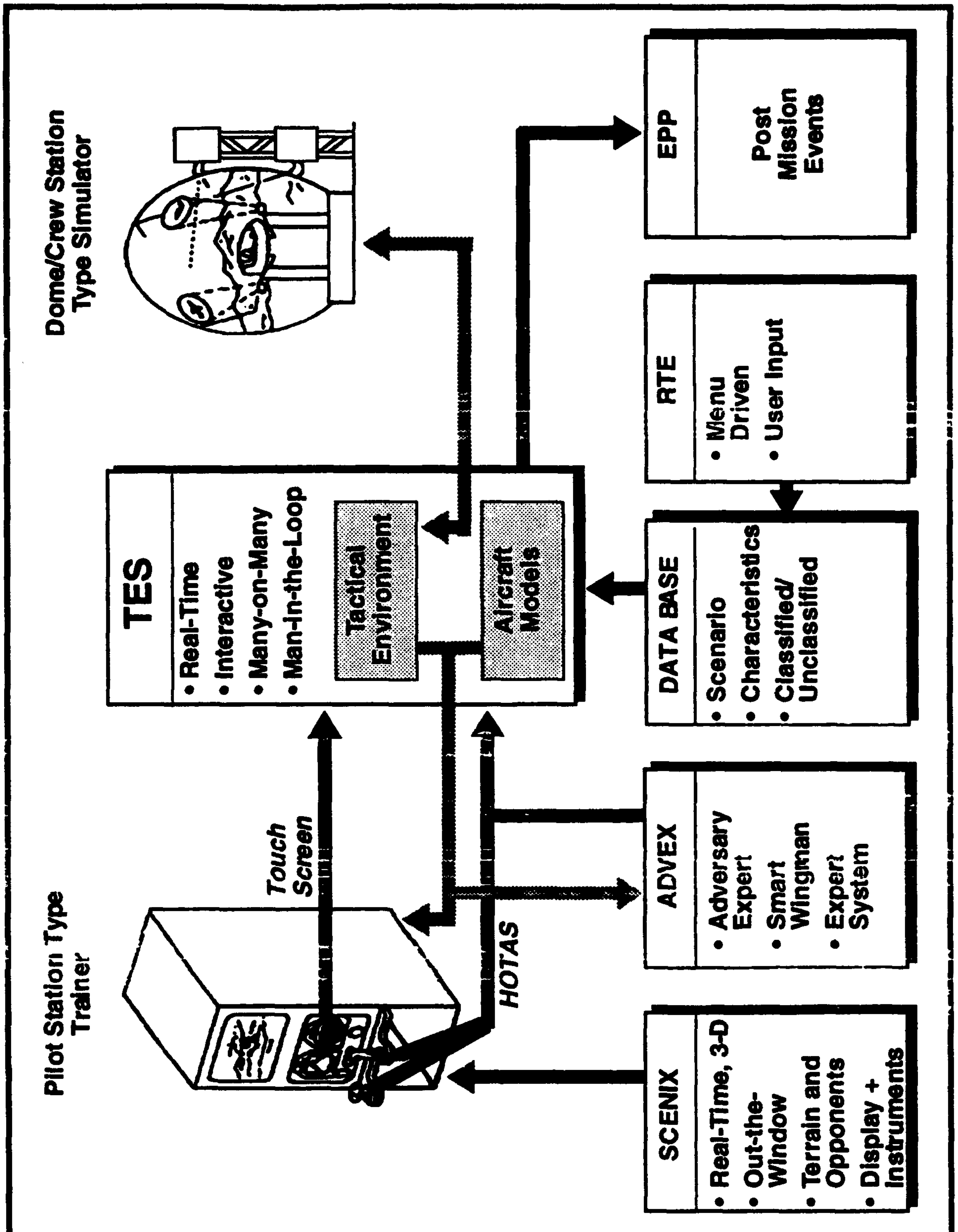

FIGURE 7.2.5.1-1 TES ARCHITECTURE

The primary pilot station comprises the following elements:

- SGI ONYX/2 RE^2 for presentation of the out-the-window display and the HUD
- SGI 4D/320VGXT for the head-down display that presents the in-cockpit controls and displays
- set of Hands-on-Throttle-and-Stick (HOTAS) flight controls
- touch screen mounted on the head-down display
- pilot station enclosure.

An auxiliary pilot station comprises the following elements:

- SGI 4D/120GTX that presents a composite out-the-window display, HUD, and head-down display
- set of generic HOTAS flight controls
- touch screen.

Use of the Tactical Environment Simulation

The Tactical Environment Simulation (TES) would be placed on the network in order to provide realistic:

a) targets for the sensors to detect,
b) ground and aircraft targets to be targeted and fired at with the aircraft's weapons,
c) threat radars which will activate RWRs and against which RF jammers can be employed, and
d) threat missiles which will activate IRWRs and against which IR jammers, chaff, and flares can be employed.

This system is proposed for use at the earliest practical stage of the development process to provide a realistic test environment for a "test it as you would fight it" approach to validation. The development of subsystem software modules so they could interface with the DIS network would permit embedding them in a validated threat environment and exercising their response over the full design range. In this way software elements, like individual sensor or weapon systems, can be tested against tactical elements at an early stage, prior to as well as after system aggregation. This testing is not intended to replace conventional unit, segment, device and system test, but will supplement it in a way that will enhance credibility and likely accelerate simulator acceptance testing. As a specific example consider testing of the ARWA radar. With TES, the radar would be positioned at a specific position and altitude within the gaming area. Target aircraft would then be positioned at desired locations within the gaming area, at different altitudes, to determine the radar's ability to detect targets of known or specified radar cross-section in the presence of clutter. Tests could be rapidly conducted at many combinations of sensor altitude, target altitude, range and cross-section and radar mode to test if the radar behaves according to specification (verification) and in a realistic manner (validation). Following these tests, effects of jamming on detection range could be evaluated including burn-through ranges. Similarly, the effects of ownship warning receivers, jammers, weapons or other subsystems that interact with tactical elements or terrain can be tested.

An upgrade to DIS 2.0 protocols and integration into the test LAN at the development site(s) would be required to implement this capability.

The full up simulator would be validated during engagement with TES and ModSAF threats using a combination of subjective evaluation (cognizant pilots with applicable experience) and objective evaluation. The goal will be to ensure that the simulators realistically represent the flight dynamics and crew environment of the actual aircraft.

ALWSIM - Close Combat Simulation

SPARTA has extensive experience in the development and use of large scale battle/combat simulations relating to land combat systems, air defense systems, command and control systems, fixed and rotary winged aircraft, and strategic weapon systems. SPARTA has developed the Army Laser Weapon Simulation (ALWSIM). which is a high resolution combined arms simulation of close combat between opposing forces that may include armor, artillery, infantry, aircraft, and air defense. ALWSIM is primarily a to performing system effectiveness and directed energy weapon analysis. DARPA c SPARTA to use ALWSIM to validate the performance of the SIMNET-D. Several key features of ALWSIM include; modeling of tactics at the platoon level and below, response of vehicles and small units to enemy actions, digitized terrain, and modeling of the battlefield environment effects of smoke and artillery dust. SPARTA provided support in the modeling of weapons and associated target effects in SIMNET-D, modeling of the human responses to the effects of battlefield lasers, and used ALWSIM to perform force-on-force simulation and analysis of DARPA programs.

ALWSIM will be used in several areas: validation of phenomenology and characteristics of the ARWA SS modules, development of scenarios, investigation of expanded scenarios, and to run many replications to determine the outcome of the scenarios.

7.3 SPECIFIC VALIDATION ACTIVITIES

7.3.1 VSM

The Visual System Module (VSM) will validated, in conjunction with the FSM and aircraft kits, to insure the visual and sensor images, moving models, lighting, environmental scenes, crew station interfaces, and out-the-window displays provide an accurate representation of the scenario being generated as well as a realistic visual effect to the pilot/co-pilot.

Table 7.3.1 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.1 Structure and Output Validation Activities for the VSM

7.3.2 FSM

7.3.2.1 FSM Base

The Flight System Module (FSM) will validated, in conjunction with the VSM and aircraft kits, to insure the crew station interfaces (controls, switches, alarms, and other devices) provide an accurate response in the scenario being generated as well as a realistic visual effect to the pilot/co-pilot.

Table 7.3.2.1 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.2.1 Structure and Output Validation Activities for the FSM Base

7.3.2.2 FSM Comanche

Table 7.3.2.2 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.2.2 Structure and Output Validation Activities for the FSM Comanche

7.3.2.3 FSM Longbow

Table 7.3.2.3 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.2.3 Structure and Output Validation Activities for the FSM Longbow

7.3.3 SSM

7.3.3.1 RAH-66 Comanche Kit

Table 7.3.3.1 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.1 Structure and Output Validation Activities for RAH-66 Comanche Kit

7.3.3.1.1 RAH-66 Flight Controls

The ARWA RAH-66 flight controls will be quantitatively validated against reference (engineering simulator output) data to assure the validity of the simulation. The following list enumerates tests to be conducted in the engineering simulator and duplicated in the ARWA RAH-66 simulator. During each of these tests the appropriate control position and applied force will be recorded. Time histories and cross plots of these parameters will be compared with reference data to validate the simulation hardware and software models. These tests will be performed with applicable trim and stability augmentation systems both on and off to confirm the effects of these systems on control forces and dynamic characteristics.

Quantitative Flight Control Validation Tests

1) Longitudinal Cyclic Control Full Range Sweep (Ground, Static)
2) Lateral Cyclic Control Full Range Sweep (Ground, Static)
3) Primary Collective Control Full Range Sweep (Ground, Static)
4) Secondary Collective Control Full Range Sweep (Ground, Static)
5) Pedal Control Full Range Sweep (Ground, Static)
6) Control System Freeplay (Ground, Static)
7) Trim System Rates
8) AFCS Override Forces
9) Control System Free Response to Step Inputs (Hover)
10) Control System Free Response to Step Inputs (Cruise)

The validation of the primary flight controls, AFCS and Flight Director will be supplemented by the tests to be performed in the flight dynamics validation (see Section 7.3.3.1.6). Due to the intimate coupling between the flight controls and the flight dynamics many of the tests described in the flight dynamics validation will also serve to validate these modules simultaneously. Secondary controls operation, such as the position vs. force relationship for the gear handle operation, will be validated subjectively during the course of these tests. The effects of battle damage to the flight controls will be validated by subjective pilot evaluation substantiated with engineering analysis of the resultant effects.

Table 7.3.3.1.1 shows the structure and output validation activities that are to be performed during each development phase of this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.1.1 Structure and Output Validation Activities for RAH-66 Flight Controls

7.3.3.1.2 RAH-66 Nav/Comm

<u>HARS/AHRS</u>, DNS, GPS
TBD

<u>ICS, VHF, UHF COMM</u>

Validation of the switch settings should be accomplished as part of the Flight Station Module validation. The only model or software validation should be of the intervisibility or line of sight computations.

<u>AIR DATA</u>

Validation consists of checking that the data reported by the ADSS equals that generated by the respective segment and is modified as necessary due to changes in power status, battle damage, and on/off adaptability parameter.

<u>ATHS</u>

Validation of incoming messages will be accomplished by comparing messages received by the Flight Station segment with messages that were received from the DIS network. Validation of outgoing messages will be accomplished by comparing messages constructed by crew member inputs from the Flight Station with messages that are passed to the Environment segment for transmission onto the DIS network. Messages shall be sent/received when radio status and frequency are properly set, and not sent/received when radio status and frequency are not properly set.

MOVING MAP

Validation of the moving map will be accomplished by comparing its appearance, controls, display and operation with real world equipment. The accuracy of ownship position will be determined by comparing the position as presented on the moving map display with the position as determined by other navigation systems.

Table 7.3.3.1.2 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.1.2 Structure and Output Validation Activities for RAH-66 Nav/Comm

7.3.3.1.3 RAH-66 Weapons

Validation of weapon models will utilize available validated models (i.e., ALWSIM) or other validated data source (AMSAA trajectory data or plots and dispersion data) to insure realistic model performance.

Validate the realism of ownship combat damage through the use of SMEs and by comparing simulated results with test results. Specifically, assess the realism of the probabilities of kill and damage that are computed as a function of the weapon (warhead) and its detonation location relative to the predefined aircraft zones.

VULCAN II 20mm Gun

Compare flyout and dispersion patterns to those generated by model INCURSION embedded in ALWSIM. AMSAA models are available to provide additional dispersion and hit data for various targets.

Validate at the segment level by testing to see that the weapon operates as follows in a realistic manner:

- bullets can be loaded and the number of rounds is properly displayed
- gun can be selected and armed (master arm)
- gun correctly positioned (AUTO/CLOSED/LOAD/DEPLOY)

- gun can be targeted within correct azimuth and elevation limits
- gun can be fired - trigger 1st and 2nd detent operation
- rounds remaining decreases properly
- bullets follow proper trajectory and impact about targeted point
- compute all data required by Environment segment for DIS PDUs

Validate the weapon system at the device and simulator system level by confirming that threats and targets on the network can be targeted, engaged and killed/damaged.

We do not have validated data for the VULCAN II 20mm gun.

2.75" FFAR MK-66

Compare flyout and dispersion patterns to those generated by model INDIRECT FIRE EFFECTS embedded in ALWSIM. AMSAA models are available to provide additional dispersion and hit data for various targets as well as limited test flight data in plot format.

Validate at the segment level by testing to see that the weapon operates as follows in a realistic manner:

- rockets can be loaded and the number of rounds is properly displayed
- rockets can be selected and armed (master arm)
- rockets can be properly targeted
- rockets can be fired - trigger 1st and 2nd detent operation
- number remaining decreases properly
- rockets follow proper trajectory and impact about targeted point
- compute all data required by Environment segment for DIS PDUs

Validate the weapon system at the device and simulator system level by confirming that threats and targets on the network can be targeted, engaged and killed/damaged.

HYDRA 70

Compare flyout and dispersion patterns to those generated by model INDIRECT FIRE EFFECTS embedded in ALWSIM.

Validate at the segment level by testing to see that the weapon operates as follows in a realistic manner:

- rockets can be loaded and the number of rounds is properly displayed
- rockets can be selected and armed (master arm)
- rockets can be properly targeted
- rockets can be fired - trigger 1st and 2nd detent operation
- number remaining decreases properly
- rockets follow proper trajectory and impact about targeted point
- compute all data required by Environment segment for DIS PDUs

Validate the weapon system at the device and simulator system level by confirming that threats and targets on the network can be targeted, engaged and killed/damaged.

We do not have access to validated data for the HYDRA 70.

AGM-114A LASER HELLFIRE

Use PHI model in ALWSIM for laser target acquisition probability comparison.

Validate at the segment level by testing to see that the weapon operates as follows in a realistic manner:

- missiles can be loaded and the number of rounds is properly displayed
- missiles can be selected in desired sequence and armed (master arm)
- missiles can be properly targeted
    - target must be within kinematic range of missile
    - target must be designated with correct code
    - can be designated autonomously or remotely
    - seeker must acquire (function of range/weather, CLOS)
    - designated target within seeker azimuth and elevation FOV limits
    - aircraft launch constraints must be met
    - indirect fire and lock-on-after-launch modes
- missiles can be fired - trigger 1st and 2nd detent operation
- missiles fire in selected order
- number remaining, and their location, properly displayed
- missiles follow proper trajectory and impact target
- compute all data required by Environment segment for DIS PDUs

Validate the weapon system at the device and simulator system level by confirming that threats and targets on the network can be targeted, engaged and killed/damaged.

We have not identified a source for validated LASER HELLFIRE trajectory data but AMSAA can provide weapon test flight data in plot format.

Air To Air Stinger (ATAS)

Use FLIR90 model in ALWSIM for IR target acquisition, tracking, and end-game probability comparison. Use ALWSIM for generation of comparison flyouts.

Validate at the segment level by testing to see that the weapon operates as follows in a realistic manner:

- missiles can be loaded and the number of rounds is properly displayed
- missiles can be selected in desired sequence and armed (master arm)
- missiles can be properly targeted to obtain "SHOOT" cue
    - seeker must acquire (function of range/weather, CLOS, target IR intensity)
    - seeker slaves to targeting system
    - designated target within seeker azimuth and elevation FOV limits
    - seeker provides cue for tone
- missiles can be fired - trigger 1st and 2nd detent operation
- missiles fire in selected order
- number remaining, and their location, properly displayed
- missiles follow proper trajectory and impact target
- compute all data required by Environment segment for DIS PDUs

Validate the weapon system at the device and simulator system level by confirming that threats and targets on the network can be targeted, engaged and killed/damaged.

We have not identified a source for validated ATAS trajectory data but AMSAA can provide weapon test flight data in plot format.

Table 7.3.3.1.3 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.1.3 Structure and Output Validation Activities for RAH-66 Weapons

7.3.3.1.4 RAH-66 Sensors

The Night Vision and Electronic Sensors Directorate of AMSAA has been involved with the verification and validation of sensor displays in the past and should be involved with our current effort. Previous sensor display evaluation at AMSAA have focused on the results of an initiative on the ACQSIM Simulation for Target Acquisition.

The sensor validation process should include collection of CIG display characteristics and calibration methodologies to provide CIG metrics for the simulated acquisition sensors. A series of tests would then be conducted on the simulator to determine the functions which describe the deviations between observer simulated target response and the real world, and to determine how great a departure from reality can be tolerated. Additional testing with trained crewmen to determine if the simulator and models produce realistic detection and acquisition results as a full demo/face validation.

The validation activity for the TADS will be to validate that the data used in the adaptability parameters accurately represents the performance of the TADS.

Table 7.3.3.1.4 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.1.4 Structure and Output Validation Activities for RAH-66 Sensors

7.3.3.1.5 RAH-66 ASE

Radar Warning APR-39 (V)1 (V)2
APR-48

The task is to validate that if the Tactical and Natural Environment (TNE) Segment emission environment contains RF signals which are then represented by protocol data units (PDUs), then the APR-39 and APR-48 would detect, identify, and generate the correct alerts.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the radar warning adaptability parameters; EID file; threat emitter type, location, power, mode, and beam characteristics; and ownship location and orientation:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensors
- identification in accordance with EID file and emitter beam parameters
- maximum detection range and range estimate from ID, EID file and detected power
- detection/no detection from maximum range and threat and ownship locations
- coarse radar site list for radar warning receiver and radar jammer operation
- emitter mode (search, acquisition, track, or missile activity) from EID file and emitter beam characteristics and activity
- emitter relative bearing from AOA information and ownship heading
- emitter priority based on priority in EID file, detecting equipment and range

- emitter location based on range and bearing
- emitter location based on triangulation processing by multiple team members
- radar warning indications (up to 8 visual effects and up to 5 visual effects), prioritized target list and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the radar warning adaptability parameters

Validate the system at the device and simulator system level by confirming that it will detect threats that are on the network and cause the appropriate warnings to be activated.

NEEDED: APR-39 (V)1 (V)2, APR-48 performance description.

Radar Jammer ALQ-136 (V)1/5

The task is to validate that the radar jammer outputs defined in the PDU accurately depict the signals that would jam the radars detected by the RWR.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the radar jammer adaptability parameters; EID file; course radar site list; and ownship location and orientation:

- equipment functional status from electric power indications, ECM enable status and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or antennas
- emitter detected if on course radar site list generated by radar warning receiver
- emitter prioritized in accordance with EID file and range between emitter site location and ownship location
- AOA evaluations using ownship angular position values, actual earth axis azimuth and elevation to the emitter, and EID file error indications
- radar jamming parameters using results of the AOA evaluations, the RF emitter's beam parameters and the EID file jamming indications
- RF jamming characteristics required to effectively simulate the jamming of the selected emitters (up to 10) and other interface parameters computed and passed
- jamming characteristics can be modified within the limits of the radar jammer adaptability parameters

Validate the system at the device and simulator system level by confirming that it will realistically jam RF threats that are on the network.

NEEDED: ALQ-136 (V)1/5 performance description.

Laser Warning AVR-2 (V) TBD

The task is to validate that if the Tactical and Natural Environment (TNE) Segment emission environment contains laser signals, then the AVR-2 would detect, identify, and generate the correct alerts.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the laser warning adaptability parameters; laser ID file; laser type, location, power, code, and beam characteristics; and ownship location and orientation:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensors
- identification in accordance with laser ID file and laser beam parameters
- maximum detection range and range estimate from ID, laser ID file and detected power
- detection/no detection from maximum range and laser and ownship locations
- laser code from laser ID file and laser beam characteristics
- laser relative bearing from AOA information and ownship heading
- laser priority based on priority in laser ID file and range
- emitter location based on range and bearing
- emitter location based on triangulation processing by multiple team members
- laser warning indications (up to TBD visual effects and up to TBD visual effects), prioritized target list and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the IR warning adaptability parameters

Validate the system at the device and simulator system level by confirming that it will detect threats that are on the network and cause the appropriate warnings to be activated.

NEEDED: AVR-2 (V) performance description.

<u>IR Jammer</u> ALQ-144 (V)1/3

The task is to validate that the IR jammer outputs defined in the PDU accurately depict the signals that would jam IR sensors.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the IR jammer adaptability parameters; IR jammer characteristics; location of IR seeker; and ownship location:

- equipment functional status from electric power indications, ECM enable status and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or IR element
- IR jamming parameters for simulation of the cooldown and warmup cycling technique
- IR jamming characteristics and other interface parameters computed and passed
- jamming characteristics can be modified within the limits of the IR jammer adaptability parameters

Validate the system at the device and simulator system level by confirming that it will realistically jam IR threats that are on the network.

NEEDED: ALQ-144 (V)1/3 performance description.

<u>Radiation Warning</u> RWS

The task is to validate that if the Tactical and Natural Environment (TNE) Segment emission environment contains radiation effects, then the RWS would detect, identify, and generate the correct alerts.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the radiation warning adaptability parameters; radiological ID file; radiation type, location, source intensity; and ownship location:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensor
- detectable/not detectable from radiation type
- intensity level at ownship from source intensity and range between radiation source location and ownship location
- detection/no detection from radiation ID file detection threshold and radiation intensity level at ownship
- radiological alert indication and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the radiation warning adaptability parameter

Validate the system at the device and simulator system level by confirming that it will detect radiation that is simulated on the network and cause the appropriate warnings to be activated.

NEEDED: RWS performance description.

Chemical Warning CWS

The task is to validate that if the Tactical and Natural Environment (TNE) Segment emission environment contains chemical agents, then the CWS would detect, identify, and generate the correct alerts.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the chemical warning adaptability parameters; chemical ID file; chemical type, cloud center location, cloud radius, cloud density; and ownship location:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensor
- detectable/not detectable from chemical type
- ownship within/not within chemical cloud based on cloud radius, cloud center location and ownship location
- detection/no detection from chemical ID file detection threshold and chemical density level at ownship
- chemical alert indication and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the chemical warning adaptability parameters

Validate the system at the device and simulator system level by confirming that it will detect chemical clouds that are simulated on the network and cause the appropriate warnings to be activated.

NEEDED: CWS performance description.

Table 7.3.3.1.5 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.1.5 Structure and Output Validation Activities for RAH-66 ASE

7.3.3.1.6 RAH-66 Flight Dynamics

The ARWA RAH-66 flight dynamics will be quantitatively validated against reference (engineering simulator output) data to assure the validity of the simulation. The following tables enumerate tests to be conducted in the engineering simulator and duplicated in the ARWA RAH-66 simulator. During each of these tests the appropriate control positions, pilot applied forces, propulsion parameters and aircraft state variables will be recorded. Time histories and cross plots of these parameters will be compared with reference data to validate the simulation hardware and software models. These tests will be performed over a representative range of flight conditions covering the aircraft operating envelope and with each applicable aircraft configuration to confirm the effects on the aircraft flight dynamics. The tests will be repeated with stability augmentation on and off to demonstrate the appropriate effects.

Quantitative Performance Validation Tests

1) One Engine Inoperative Takeoff Performance
2) Hover Performance (IGE, OGE)
3) Normal Climb Performance
4) Engine Out Climb Performance
5) Cruise Performance
6) Normal Descent Performance

Quantitative Handling Qualities Validation Tests

1) Low Speed Translational Flight (Forward, Aft, Left, Right)

2) Critical Azimuth Stationary Hover
3) Control Response in Hover (Long., Lateral, Directional, Vertical)
4) Longitudinal Control Response to Step Inputs
5) Longitudinal Static Stability
6) Longitudinal Dynamic Stability, Long Term
7) Longitudinal Dynamic Stability, Short Term
8) Longitudinal Maneuvering Stability
9) Lateral Response to Step Inputs
10) Directional Response to Step Inputs
11) Directional Static Stability
12) Lateral/Direction Dynamic Stability
13) Spiral Stability
14) Adverse/Proverse Yaw
15) Vertical Response to Primary Collective Step Inputs
16) Vertical Response to Secondary Collective Step Inputs

The quantitative evaluation of the flight dynamics will be supplemented with a subjective evaluation of the ARWA RAH-66 simulator handling qualities. In this phase of the evaluation it is a fundamental requirement to utilize pilots who are intimately familiar with the RAH-66 flight dynamics and performance. Access to the engineering simulator will be provided to the evaluation pilots prior to and during this assessment. The use of at least 3 qualified pilots will insure a thorough and accurate evaluation of the simulator. The following table lists the flight operations to be performed during the subjective evaluation. Tests in which flight director guidance is applicable will be duplicated using the flight director engaged and utilized as the primary reference.

During the handling qualities assessment each of the following criteria will be addressed: a) aircraft stability, b) aircraft controllability, c) pilot workload, d) precision of task, e) appropriateness of control inputs and f) correlation of visual, aural and motion cues to flight condition. The pilots will check that the ARWA RAH-66 simulator reproduces fidelity of flight operations to a level which will closely resemble that of the engineering simulator and which will not cause either distraction of the pilot or an increase or decrease in the performance of the air vehicle to an extent that would affect combat effectiveness or associated test results.

Handling Qualities Assessment Tests

1) Hovering Turns With Wind
2) Rejected Takeoff
3) Aborted Landing
4) Nap of the Earth Flight Over Terrain
5) Ground Target Tracking
6) Ground Attack Weapon Delivery
7) Ground To Air Weapon Avoidance
8) Air Target Tracking
9) Air to Air Combat Maneuvering

10) Air to Air Weapon Firing
11) Air to Air Weapon Avoidance
12) Flight with Selected Combinations of Ordinance Installed
13) Flight With Selected Propulsion System Battle Damage
14) Flight With Selected Flight Control Battle Damage
15) Flight With Selected AFCS Battle Damage
16) Flight With Selected Airframe Battle Damage

The effects of battle damage to the flight controls will be validated by subjective pilot evaluation substantiated with engineering analysis of the resultant effects.

Table 7.3.3.1.6 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.1.6 Structure and Output Validation Activities for RAH-66 Flight Dynamics

7.3.3.1.7 RAH-66 Propulsion

The ARWA RAH-66 engine and propulsion system will be quantitatively validated against reference (engine deck and engineering simulator output) data to assure the validity of the simulation. The following list enumerates tests to be conducted and duplicated in the ARWA RAH-66 simulator. During each of these tests the appropriate engine and propulsion system parameters (Gas generator speed, Power turbine speed, Fuel flow, Engine torque, Turbine gas temperature, Engine oil pressure and temperature, Main rotor speed and Tail rotor speed) will be recorded. Time histories and cross plots of these parameters will be compared with reference data to validate the simulation software models. These tests will be performed at applicable temperatures, airspeeds and altitudes to include the operating envelope of the RAH-66.

Quantitative Engine and Propulsion System Validation Tests

1) Rapid Engine Accelerations
2) Rapid Engine Decelerations
3) Nominal Rate Engine Accelerations
4) Nominal Rate Engine Decelerations
5) Steady State Engine Operation
6) Power Turbine Trim Speed Change Response
7) Engine and Rotor Speed Governing Demonstration

The validation of the engine and propulsion system may be supplemented by the tests to be performed in the flight dynamics validation (see Section 7.3.3.1.6) depending upon the model design and complexity. Due to the intimate coupling between the propulsion system and the flight dynamics many of the tests described in the flight dynamics validation may also serve to validate these modules simultaneously. The effects of battle damage to the propulsion system may also be validated by subjective evaluation substantiated with engineering analysis of the resultant effects.

Table 7.3.3.1.7 shows the structure and output validation activities that may be performed during each development phase of this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.1.7 Structure and Output Validation Activities for RAH-66 Propulsion

7.3.3.1.8 RAH-66 Physical Cues

Validation will consist of the insuring proper sensory cues are provided for the varied environmental effects available in each test.

Table 7.3.3.1.8 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.1.8 Structure and Output Validation Activities for RAH-66 Physical Cues

7.3.3.1.9 RAH-66 TNE

The Tactical and Natural Environment segment will receive special attention for, through it, the ARWA SS interfaces with the rest of the Multiple Simulator Environment (MSE). And since these data then flow to and from the other segments of the RAH-66 Simulator System Module, in order to interact with/stimulate their models, the proper implementation and functioning of the TNE segment is crucial to the proper functioning of the entire RAH-66 Simulator System Module. Validation at the segment level will require tests of the following areas to verify that the functions operate properly:

<u>TNE Segment Support Function</u>

- Executive Control support service which provides operational control for the TNE segment
- Initialization support service which controls initial hardware and software states for the TNE segment
- ARWA SS Inter-Segment Communication support service which provides the TNE segment interface through the ARWA SS architecture

<u>Atmosphere Function</u>

- Provides ambient atmospheric data as a function of altitude
- Provides the specific atmospheric model
- Provides commanded atmospheric effects such as wind and turbulence

<u>Database Management Function</u>

- Provides control of the ARWA SS databases before, and during, a real-time experiment. This function shall:
  - filter out those entities which are beyond a specified range in order to reduce the scope of actively modeled entities
  - process logical and data faults around the gaming areas
  - provide the management of dynamic database elements, as a minimum, the location of platform entity crash sites
  - maintain a list of the terrain and culture points within the gaming area that have been damaged, or otherwise affected, in an experiment
  - the reference database provides the background terrain and culture definition required for resolution of spatial relations, occulting, etc.

Spatial Relations Function

- Provides models that characterize the relationship between a vehicle and elements of the natural and tactical environment. This function will:
  - determine the slant range from a specified entity to natural and tactical entities in the gaming area
  - calculate height above terrain, for a specified entity, based upon the terrain characteristics contained in the terrain database
  - detect the occurrence of collisions between a specified entity and entities or terrain with which it can collide

Occulting Function

- Determines the line-of -sight continuity between any object or designated area and the ownship, or for other objects in the simulation

Ownship Weapons' Damage Assessment Function

- Provides damage data for each simulated ownship weapon fired during a real-time experiment

Entity Management Function

- Simulates the physical characteristics of all active platforms in a real-time experiment.
  - it shall use the appropriate dead reckoning algorithms, as defined by the MSE for each entity generated by the MSE, to update their position and attitude between update messages
  - it shall integrate the updated information about the entity state in order to produce a seamless simulation of the entity within the ownship

Entity Database Function

- Provides an extensive and detailed description of the non-ownship entities that may be active in an experiment. It shall also provide for the generation and maintenance of the entity data.

Entity Weapons Function

- Simulates the firing and flight track of weapons detectable to the ownship during a real-time experiment. It shall:
  - activate, fly and deactivate weapons in accordance with instructions from the Entity Management function
  - model all of the control and operation parameters for weapon entities, based on control requests

- accept command, control and position information from the MSE Interaction function describing weapons which are created and controlled by other simulators in the MSE
- integrate this information into a seamless simulation of weapon entities
- model the flight path fidelity of weapon entities
- model the mass properties of weapon entities

Entity Expendable Countermeasure Function

- Simulates deployment of expendable countermeasures (e.g. chaff and flares) from non-ownship platforms during a experiment. Expendable countermeasures dispensing will be controlled by other simulators.

MSE Interaction Function

- Provides the communication protocol and data formats required for interaction between the TNE segment and the MSE.
- The MSE interaction function shall provide all formatting, conversion, and communication required for the TNE segment to communicate within the MSE
- Communications shall use the DIS protocol
- Communications between simulators in the MSE shall occur via DIS LAN.

Validation of the TNE segment at the device and simulator system/MSE level will require tests of the following areas to verify that the functions operate properly:

- Create a scenario with one, then multiple, ownships, terrain, threats, targets and other tactical elements. Cause elements of the tactical threat environment to take actions that will provide stimuli for all RAH-66 weapon systems.
- Employ all ownship sensors to detect threats and targets. Confirm that the sensors operate realistically.
- Employ all ASE systems to detect threats and to defeat them through RF and IR jamming and the employment of chaff and flares. Confirm that the ASE systems operate realistically.
- Target both air and ground targets and employ all air-to-air and air-to-ground weapons against them. Confirm that all RAH-66 weapon systems can kill or damage and that they operate realistically.
- Employ all nav/com systems and confirm that they operate realistically.
- Confirm that the visuals are present and are updated smoothly.
- Confirm all special effects and physical cues are presented in a realistic manner.
- Confirm that all controls and displays operate in a realistic manner.
- When ownship receives fire, confirm that damage received is realistic.

Table 7.3.3.1.9 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.1.9 Structure and Output Validation Activities for RAH-66 TNE

7.3.3.2 AH-64D Longbow Kit

Table 7.3.3.2 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.2 Structure and Output Validation Activities for AH-64D Longbow Kit

7.3.3.2.1 AH-64D Flight Controls

The ARWA AH-64D flight controls will be quantitatively validated against reference (flight test) data to assure the validity of the simulation. The following list enumerates tests to be conducted in flight test and duplicated in the ARWA AH-64D simulator. During each of these tests the appropriate control position and applied force will

be recorded. Time histories and cross plots of these parameters will be compared with reference data to validate the simulation hardware and software models. These tests will be performed with applicable trim and stability augmentation systems both on and off to confirm the effects of these systems on control forces and dynamic characteristics.

Quantitative Flight Control Validation Tests

1) Longitudinal Cyclic Control Full Range Sweep (Static)
2) Lateral Cyclic Control Full Range Sweep (Static)
3) Primary Collective Control Full Range Sweep (Static)
4) Pedal Control Full Range Sweep (Static)
5) Control System Freeplay (Static)
6) Trim System Rates
7) AFCS Override Forces
8) Control System Free Response to Step Inputs (Hover)
9) Control System Free Response to Step Inputs (Cruise)

The validation of the primary flight controls, AFCS and Flight Director will be supplemented by the tests to be performed in the flight dynamics validation (see Section 7.3.3.2.6). Due to the intimate coupling between the flight controls and the flight dynamics many of the tests described in the flight dynamics validation will also serve to validate these modules simultaneously. Secondary controls operation, such as the position vs. force relationship for the gear handle operation, will be validated subjectively during the course of these tests. The effects of battle damage to the flight controls will be validated by subjective pilot evaluation substantiated with engineering analysis of the resultant effects.

Table 7.3.3.2.1 shows the structure and output validation activities that are to be performed during each development phase of this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.2.1 Structure and Output Validation Activities for AH-64D Flight Controls

7.3.3.2.2 AH-64D Nav/Comm

INU, DVRS, GPS

TBD

ICS, VHF, UHF COMM

Validation of the switch settings should be accomplished as part of the Flight Station Module validation. The only model or software validation should be of the intervisibility or line of sight computations.

AIR DATA

Validation consists of checking that the data reported by the ADSS equals that generated by the respective segment and is modified as necessary due to changes in power status, battle damage, and on/off adaptability parameter.

IMPROVED DATA MODEM (IDM)

Validation of incoming messages will be accomplished by comparing messages received by the Flight Station segment with messages that were received from the DIS network. Validation of outgoing messages will be accomplished by comparing messages constructed by crew member inputs from the Flight Station with messages that are passed to the Environment segment for transmission onto the DIS network. Messages shall be sent/received when radio status and frequency are properly set, and not sent/received when radio status and frequency are not properly set.

Table 7.3.3.2.2 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.2.2 Structure and Output Validation Activities for AH-64D Nav/Comm

7.3.3.2.3 AH-64D Weapons

Validation of weapon models will utilize available validated models (i.e., ALWSIM) or other validated data source (AMSAA trajectory plots and dispersion data) to insure realistic model performance..

Validate the realism of ownship combat damage through the use of SMEs and by comparing simulated results with test results. Specifically, assess the realism of the probabilities of kill and damage that are computed as a function of the weapon (warhead) and its detonation location relative to the predefined aircraft zones.

M-230E1 30mm Gun

Compare flyout and dispersion patterns to those generated by model INCURSION embedded in ALWSIM. AMSAA models are available to provide additional dispersion and hit data for various targets.

Validate at the segment level by testing to see that the weapon operates as follows in a realistic manner:

- bullets can be loaded and the number of rounds is properly displayed
- gun can be selected and armed (master arm)
- gun correctly positioned (AUTO/CLOSED/LOAD/DEPLOY)
- gun can be targeted within correct azimuth and elevation limits
- gun can be fired - trigger 1st and 2nd detent operation
- rounds remaining decreases properly
- bullets follow proper trajectory and impact about targeted point
- compute all data required by Environment segment for DIS PDUs

Validate the weapon system at the device and simulator system level by confirming that threats and targets on the network can be targeted, engaged and killed/damaged.

2.75" FFAR MK-66

Compare flyout and dispersion patterns to those generated by model INDIRECT FIRE EFFECTS embedded in ALWSIM. AMSAA models are available to provide additional dispersion and hit data for various targets as well as limited test flight data in plot format .

Validate at the segment level by testing to see that the weapon operates as follows in a realistic manner:

- rockets can be loaded and the number of rounds is properly displayed
- rockets can be selected and armed (master arm)
- rockets can be properly targeted
- rockets can be fired - trigger 1st and 2nd detent operation
- number remaining decreases properly
- rockets follow proper trajectory and impact about targeted point
- compute all data required by Environment segment for DIS PDUs

Validate the weapon system at the device and simulator system level by confirming that threats and targets on the network can be targeted, engaged and killed/damaged.

<u>AGM-114A LASER HELLFIRE</u>

Use PHI model in ALWSIM for laser target acquisition probability comparison.

Validate at the segment level by testing to see that the weapon operates as follows in a realistic manner:

- missiles can be loaded and the number of rounds is properly displayed
- missiles can be selected in desired sequence and armed (master arm)
- missiles can be properly targeted
    - target must be within kinematic range of missile
    - target must be designated with correct code
    - can be designated autonomously or remotely
    - seeker must acquire (function of range/weather, CLOS)
    - designated target within seeker azimuth and elevation FOV limits
    - aircraft launch constraints must be met
    - indirect fire and lock-on-after-launch modes
- missiles can be fired - trigger 1st and 2nd detent operation
- missiles fire in selected order
- number remaining, and their location, properly displayed
- missiles follow proper trajectory and impact target
- compute all data required by Environment segment for DIS PDUs

Validate the weapon system at the device and simulator system level by confirming that threats and targets on the network can be targeted, engaged and killed/damaged.

We have not identified a source for validated LASER HELLFIRE trajectory data but AMSAA can provide weapon test flight data in plot format .

<u>AGM-114F RF HELLFIRE</u>

Use ACQUIRE model in ALWSIM for radar acquisition, tracking performance, and probability comparison. Use ALWSIM for generation of HELLFIRE comparison flyouts.

Validate at the segment level by testing to see that the weapon operates as follows in a realistic manner:

- missiles can be loaded and the number of rounds is properly displayed
- missiles can be selected in desired sequence and armed (master arm)
- missiles can be properly targeted
    - target must be within kinematic range of missile
    - target must be illuminate with correct code
    - can be designated autonomously or remotely
    - seeker must acquire (function of range/weather, CLOS)
    - designated target within seeker azimuth and elevation FOV limits
    - aircraft launch constraints must be met
    - indirect fire and lock-on-after-launch modes
- missiles can be fired - trigger 1st and 2nd detent operation
- missiles fire in selected order
- number remaining, and their location, properly displayed
- missiles follow proper trajectory and impact target
- compute all data required by Environment segment for DIS PDUs

Validate the weapon system at the device and simulator system level by confirming that threats and targets on the network can be targeted, engaged and killed/damaged.

We have not identified a source for validated RF HELLFIRE trajectory data but AMSAA can provide weapon test flight data in plot format .

AGM-114K RF HELLFIRE II

Use ACQUIRE model in ALWSIM for radar acquisition, tracking performance, and probability comparison. Use ALWSIM for generation of HELLFIRE comparison flyouts.

Validate at the segment level by testing to see that the weapon operates as follows in a realistic manner:

- missiles can be loaded and the number of rounds is properly displayed
- missiles can be selected in desired sequence and armed (master arm)
- missiles can be properly targeted
  - target must be within kinematic range of missile
  - target must be illuminated with correct code
  - can be designated autonomously or remotely
  - seeker must acquire (function of range/weather, CLOS)
  - designated target within seeker azimuth and elevation FOV limits
  - aircraft launch constraints must be met
  - indirect fire and lock-on-after-launch modes
- missiles can be fired - trigger 1st and 2nd detent operation
- missiles fire in selected order
- number remaining, and their location, properly displayed
- missiles follow proper trajectory and impact target
- compute all data required by Environment segment for DIS PDUs

Validate the weapon system at the device and simulator system level by confirming that threats and targets on the network can be targeted, engaged and killed/damaged.

We have not identified a source for validated RF HELLFIRE trajectory data but AMSAA can provide weapon test flight data in plot format .

Table 7.3.3.2.3 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.2.3 Structure and Output Validation Activities for AH-64D Weapons

7.3.3.2.4 AH-64D Sensors

The sensor validation process should include collection of CIG display characteristics and calibration methodologies to provide CIG metrics for the simulated acquisition sensors. A series of tests would then be conducted on the simulator to determine the functions which describe the deviations between observer simulated target response and the real world, and to determine how great a departure from reality can be tolerated. Additional testing with trained crewmen to determine if the simulator and models produce realistic detection and acquisition results as a full demo/face validation.

Table 7.3.3.2.4 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.2.4 Structure and Output Validation Activities for AH-64D Sensors

7.3.3.2.5 AH-64D ASE

Radar Warning APR-39 (V)1 (V)2
APR-48

The task is to validate that if the Tactical and Natural Environment (TNE) Segment emission environment contains RF signals which are then represented by protocol data units (PDUs), then the APR-39 and APR-48 would detect, identify, and generate the correct alerts.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the radar warning adaptability parameters; EID file; threat emitter type, location, power, mode, and beam characteristics; and ownship location and orientation:

- equipment functional status from electric power indications and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensors
- identification in accordance with EID file and emitter beam parameters
- maximum detection range and range estimate from ID, EID file and detected power
- detection/no detection from maximum range and threat and ownship locations
- coarse radar site list for radar warning receiver and radar jammer operation
- emitter mode (search, acquisition, track, or missile activity) from EID file and emitter beam characteristics and activity
- emitter relative bearing from AOA information and ownship heading
- emitter priority based on priority in EID file, detecting equipment and range

- emitter location based on range and bearing
- emitter location based on triangulation processing by multiple team members
- radar warning indications (up to 8 visual effects and up to 5 visual effects), prioritized target list and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the radar warning adaptability parameters

Validate the system at the device and simulator system level by confirming that it will detect threats that are on the network and cause the appropriate warnings to be activated.
NEEDED: APR-39 (V)1 (V)2, APR-48 performance description.

Radar Jammer ALQ-136 (V)1/5

The task is to validate that the radar jammer outputs defined in the PDU accurately depict the signals that would jam the radars detected by the RWR.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the radar jammer adaptability parameters; EID file; course radar site list; and ownship location and orientation:

- equipment functional status from electric power indications, ECM enable status and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or antennas
- emitter detected if on course radar site list generated by radar warning receiver
- emitter prioritized in accordance with EID file and range between emitter site location and ownship location
- AOA evaluations using ownship angular position values, actual earth axis azimuth and elevation to the emitter, and EID file error indications
- radar jamming parameters using results of the AOA evaluations, the RF emitter's beam parameters and the EID file jamming indications
- RF jamming characteristics required to effectively simulate the jamming of the selected emitters (up to 10) and other interface parameters computed and passed
- jamming characteristics can be modified within the limits of the radar jammer adaptability parameters

Validate the system at the device and simulator system level by confirming that it will realistically jam RF threats that are on the network.
NEEDED: ALQ-136 (V)1/5 performance description.

Laser Warning AVR-2 (V) TBD

The task is to validate that if the Tactical and Natural Environment (TNE) Segment emission environment contains laser signals, then the AVR-2 would detect, identify, and generate the correct alerts.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the laser warning adaptability parameters; laser ID file; laser type, location, power, code, and beam characteristics; and ownship location and orientation:

- equipment functional status from electric power indications and sustained battle damage

- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or sensors
- identification in accordance with laser ID file and laser beam parameters
- maximum detection range and range estimate from ID, laser ID file and detected power
- detection/no detection from maximum range and laser and ownship locations
- laser code from laser ID file and laser beam characteristics
- laser relative bearing from AOA information and ownship heading
- laser priority based on priority in laser ID file and range
- emitter location based on range and bearing
- emitter location based on triangulation processing by multiple team members
- laser warning indications (up to TBD visual effects and up to TBD visual effects), prioritized target list and other interface parameters computed and passed
- detection characteristics can be modified within the limits of the IR warning adaptability parameters

Validate the system at the device and simulator system level by confirming that it will detect threats that are on the network and cause the appropriate warnings to be activated.

NEEDED: AVR-2 (V) performance description.

<u>IR Jammer</u> ALQ-144 (V)1/3

The task is to validate that the IR jammer outputs defined in the PDU accurately depict the signals that would jam IR sensors.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the IR jammer adaptability parameters; IR jammer characteristics; location of IR seeker; and ownship location:

- equipment functional status from electric power indications, ECM enable status and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or IR element
- IR jamming parameters for simulation of the cooldown and warmup cycling technique
- IR jamming characteristics and other interface parameters computed and passed
- jamming characteristics can be modified within the limits of the IR jammer adaptability parameters

Validate the system at the device and simulator system level by confirming that it will realistically jam IR threats that are on the network.

NEEDED: ALQ-144 (V)1/3 performance description.

<u>Chaff M-I</u> M-130 Dispenser

The task is to validate that the chaff cloud characteristics defined in the PDU accurately depict chaff velocity, dispersion pattern, and radar cross section.

Validate the system at the segment level by testing that the following parameters are properly computed in accordance with the chaff adaptability parameters; pilot switch selection and actions; and ownship location:

- equipment functional status from electric power indications, chaff inventory, chaff selection and sustained battle damage
- reduced capability or total failure of the function as a result of sustained battle damage in the areas of the equipment and/or dispenser
- chaff dispensed upon command when manual mode selected
- chaff dispensed in accordance with system characteristics or adaptability parameters when automatic mode selected
- chaff inventory decremented by the number of bundles dispensed
- release indication and other interface parameters computed and passed
- delivery system characteristics and/or chaff characteristics can be modified within the limits of the chaff adaptability parameters

Validate the system at the device and simulator system level by confirming that the chaff realistically affects the performance of threat RF missiles that are on the network.

We have not identified a validated source of chaff characteristics.

NEEDED: Chaff M-I performance description.

Table 7.3.3.2.5 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.2.5 Structure and Output Validation Activities for AH-64D ASE

7.3.3.2.6 AH-64D Flight Dynamics

The ARWA AH-64D flight dynamics will be quantitatively validated against reference (flight test) data to assure the validity of the simulation. The following tables enumerate tests to be conducted in flight test and duplicated in the ARWA AH-64D simulator. During each of these tests the appropriate control positions, pilot applied forces, propulsion parameters and aircraft state variables will be recorded. Time histories and cross plots of these parameters will be compared with reference data to validate the simulation hardware and software models. These tests will be performed over a representative range of flight conditions covering the aircraft operating envelope and with

each applicable aircraft configuration to confirm the effects on the aircraft flight dynamics. The tests will be repeated with stability augmentation on and off to demonstrate the appropriate effects.

Quantitative Performance Validation Tests

1) One Engine Inoperative Takeoff Performance
2) Hover Performance (IGE, OGE)
3) Normal Climb Performance
4) Engine Out Climb Performance
5) Cruise Performance
6) Normal Descent Performance

Quantitative Handling Qualities Validation Tests

1) Low Speed Translational Flight (Forward, Aft, Left, Right)
2) Critical Azimuth Stationary Hover
3) Control Response in Hover (Long., Lateral, Directional, Vertical)
4) Longitudinal Control Response to Step Inputs
5) Longitudinal Static Stability
6) Longitudinal Dynamic Stability, Long Term
7) Longitudinal Dynamic Stability, Short Term
8) Longitudinal Maneuvering Stability
9) Lateral Response to Step Inputs
10) Directional Response to Step Inputs
11) Directional Static Stability
12) Lateral/Direction Dynamic Stability
13) Spiral Stability
14) Adverse/Proverse Yaw
15) Vertical Response to Primary Collective Step Inputs

The quantitative evaluation of the flight dynamics will be supplemented with a subjective evaluation of the ARWA AH-64D simulator handling qualities. In this phase of the evaluation it is a fundamental requirement to utilize pilots who are intimately familiar with the AH-64D flight dynamics and performance. Access to a AH-64D helicopter will be provided to the evaluation pilots prior to and during this assessment. The use of at least 3 qualified pilots will insure a thorough and accurate evaluation of the simulator. The following table lists the flight operations to be performed during the subjective evaluation. Tests in which flight director guidance is applicable will be duplicated using the flight director engaged and utilized as the primary reference.

During the handling qualities assessment each of the following criteria will be addressed: a) aircraft stability, b) aircraft controllability, c) pilot workload, d) precision of task, e) appropriateness of control inputs and f) correlation of visual, aural and motion cues to flight condition. The pilots will check that the ARWA RAH-66 simulator reproduces

fidelity of flight operations to a level which will closely resemble that of the engineering simulator and which will not cause either distraction of the pilot or an increase or decrease in the performance of the air vehicle to an extent that would affect combat effectiveness or associated test results.

Handling Qualities Assessment Tests

1) Hovering Turns With Wind
2) Rejected Takeoff
3) Aborted Landing
4) Nap of the Earth Flight Over Terrain
5) Ground Target Tracking
6) Ground Attack Weapon Delivery
7) Ground To Air Weapon Avoidance
8) Air Target Tracking
9) Air to Air Combat Maneuvering
10) Air to Air Weapon Firing
11) Air to Air Weapon Avoidance
12) Flight with Selected Combinations of Ordinance Installed
13) Flight With Selected Propulsion System Battle Damage
14) Flight With Selected Flight Control Battle Damage
15) Flight With Selected AFCS Battle Damage
16) Flight With Selected Airframe Battle Damage

The effects of battle damage to the flight controls will be validated by subjective pilot evaluation substantiated with engineering analysis of the resultant effects.

Table 7.3.3.2.6 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.2.6 Structure and Output Validation Activities for AH-64D Flight Dynamics

7.3.3.2.7 AH-64D Propulsion

The ARWA AH-64D engine and propulsion system will be quantitatively validated against reference (engine deck and flight test) data to assure the validity of the simulation. The following list enumerates tests to be conducted and duplicated in the ARWA AH-64D simulator. During each of these tests the appropriate engine and propulsion system parameters (Gas generator speed, Power turbine speed, Fuel flow, Engine torque, Turbine gas temperature, Engine oil pressure and temperature, Main rotor speed and Tail rotor speed) will be recorded. Time histories and cross plots of these parameters will be compared with reference data to validate the simulation software models. These tests will be performed at applicable temperatures, airspeeds and altitudes to include the operating envelope of the AH-64D.

Quantitative Engine and Propulsion System Validation Tests

1) Rapid Engine Accelerations
2) Rapid Engine Decelerations
3) Nominal Rate Engine Accelerations
4) Nominal Rate Engine Decelerations
5) Steady State Engine Operation
6) Power Turbine Trim Speed Change Response
7) Engine and Rotor Speed Governing Demonstration

The validation of the engine and propulsion system may be supplemented by the tests to be performed in the flight dynamics validation (see Section 7.3.3.2.6) depending upon the model design and complexity. Due to the intimate coupling between the propulsion system and the flight dynamics many of the tests described in the flight dynamics validation may also serve to validate these modules simultaneously. The effects of battle damage to the propulsion system may also be validated by subjective evaluation substantiated with engineering analysis of the resultant effects.

The effects of battle damage to the propulsion system will be validated by subjective evaluation substantiated with engineering analysis of the resultant effects.

Table 7.3.3.2.7 shows the structure and output validation activities that are to be performed during each development phase of this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.2.7 Structure and Output Validation Activities for AH-64D Propulsion

7.3.3.2.8 AH-64D Physical Cues

Validation will consist of the insuring proper sensory cues are provided for the varied environmental effects available in each test.

Table 7.3.3.2.8 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.2.8 Structure and Output Validation Activities for AH-64D Physical Cues

7.3.3.2.9 AH-64D TNE

The Tactical and Natural Environment segment will receive special attention for, through it, the ARWA SS interfaces with the rest of the Multiple Simulator Environment (MSE). And since these data then flow to and from the other segments of the AH-64D Simulator System Module, in order to interact with/stimulate their models, the proper implementation and functioning of the TNE segment is crucial to the proper functioning of the entire AH-64D Simulator System Module. Validation at the segment level will require tests of the following areas to verify that the functions operate properly:

<u>Network Interface Function</u>
- Provide for information updates conforming to the Distributed Interactive Simulation (DIS) standard.
- Provide this information to the ongoing simulation of the ownship environment as appropriate.
- Perform all necessary conversions to conform to ARWA internal data formats and units.

<u>Atmosphere Function</u>
- Provide for simulation of a medium fidelity atmosphere.
- Simulate air mass, global winds, and turbulence.
- Provide global definitions of temperature and pressure.

<u>External Entities Function</u>
- Simulate the position and attitude of other vehicles between updates from the multi-simulator environment (MSE).
- Upon receiving such updates, the TNE segment shall seamlessly inject the new data into the vehicle simulation.

<u>Ownship Weapon Damage Function</u>
- Provide to the MSE information regarding ownship weapon path, detonation and ordinance.
- The information shall be passed through to the external simulation through the Network Interface function.

<u>Threat Weapon Dynamics Function</u>
- Simulate the flight of threat weapons between updates from the MSE.

Threat Platform Dynamics Function
- Simulate the flight of threat platforms between updates from the MSE.

Validation of the TNE segment at the device and simulator system/MSE level will require tests of the following areas to verify that the functions operate properly:
- Create a scenario with one, then multiple, ownships, terrain, threats, targets and other tactical elements. Cause elements of the tactical threat environment to take actions that will provide stimuli for all AH-64D weapon systems.
- Employ all ownship sensors to detect threats and targets. Confirm that the sensors operate realistically.
- Employ all ASE systems to detect threats and to defeat them through RF and IR jamming and the employment of chaff and flares. Confirm that the ASE systems operate realistically.

- Target both air and ground targets and employ all air-to-air and air-to-ground weapons against them. Confirm that all AH-64D weapon systems can kill or damage and that they operate realistically.
- Employ all nav/com systems and confirm that they operate realistically.
- Confirm that the visuals are present and are updated smoothly.
- Confirm that all special effects and physical cues are presented in a realistic manner.
- Confirm that all controls and displays operate in a realistic manner.
- When ownship receives fire, confirm that damage received is realistic.

Table 7.3.3.2.9 shows the structure and output validation activities that are to be performed during each development phase for this component.

Phase: / Activity:	Pre-PDR	PDR-CDR	Post-CDR	CUT
Structure Validation				
Documentation and Reviews	√	√	√	
Real World Comparisons			√	
SW Architecture Assessment		√	√	
Face Validation				√
Output Validation				
Evaluate T&E Criteria		√	√	
Data Collection		√	√	
Scenario Identification		√	√	√
Models		√	√	
Test and Evaluation				√

Table 7.3.3.2.9 Structure and Output Validation Activities for AH-64D TNE

8.0 ACCREDITATION

This section defines the specific activities required for accreditation for each of the components of the ARWA SS.

8.1 VSM

TBD

8.2 FSM

TBD

8.3 SSM

TBD

8.3.1 RAH-66 Comanche Kit

TBD

8.3.1.1 RAH-66 Flight Controls

TBD

8.3.1.2 RAH-66 Nav/Comm

TBD

8.3.1.3 RAH-66 Weapons

TBD

8.3.1.4 RAH-66 Sensors

TBD

8.3.1.5 RAH-66 ASE

TBD

8.3.1.6 RAH-66 Flight Dynamics

TBD

8.3.1.7 RAH-66 Propulsion

TBD

8.3.1.8 RAH-66 Physical Cues

TBD

8.3.1.9 RAH-66 TNE

TBD

8.3.2 AH-64D Longbow Kit

TBD

8.3.2.1 AH-64D Flight Controls

TBD

8.3.2.2 AH-64D Nav/Comm

TBD

8.3.2.3 AH-64D Weapons

TBD

8.3.2.4 AH-64D Sensors

TBD

8.3.2.5 AH-64D ASE

TBD

8.3.2.6 AH-64D Flight Dynamics

TBD

8.3.2.7 AH-64D Propulsion

TBD

8.3.2.8 AH-64D Physical Cues

TBD

8.3.2.9 AH-64D TNE

TBD

9. LIST OF ACRONYMS

A/C	Aircraft
ADST	Advance Distributed Simulation Technology
AFCS	Automatic Flight Control Systems
ALWSIM	Army Laser Weapon Simulation
AMSAA	Army Material Systems Analysis Activity

ARWA SS	Advanced Rotary Wing Aircraft Simulator System
ASE	Aircraft Survivability Equipment]
ATAS	Air to Air System
ATHS/EATHS	Automatic Target Handover System / Enhanced ATHS
BDS-D	Battlefield Distributed Simulation Development
BRL	Ballistic Research Laboratory
CADC	Central Air Data Computer
CASE	Computer Aided Software Engineering
CASTFOREM	Constructive Force on Force Combat Simulation
CCB	Configuration Control Board
CIG	Computer Image Generation (Generator)
CLOS	Continuous Line Of Sight
CM	Configuration Management
COTS	Commercial Off The Shelf
CSC	Computer Software Components
CSCI	Computer Software Configuration Items
CSU	Computer Software Units
CUT	Code and Unit Test
DIS	Distributed Interactive Simulation
DNS	Doppler Navigation System
DO	Delivery Order
EDASE	Enhanced Digital Automatic Stabilization Equipment
FFAR	Folding Fin Aerial Rocket
FLIR	Forward Looking Infra-Red
FSM	Flight Station Module
GFE	Government Furnished Equipment
GPS	Global Positioning System
GROUNDWARS/GWARS	Force-on-Force combat simulation using Night Vision Laboratory models
HARS/AHRS	Heading and Attitude Reference System
IDD	Interface Design Definition
IDM	Improved Data Modem
IRS	Interface Requirements Specification
LAN	Local Area Network
LORAM	Low Observable Radar Model
LWR	Laser Warning Receiver
METL	Mission Essential Task List

ModSAF	Modular Semi-Automated Forces
MRC	Minimum Resolvable Contrast
MRTD	Minimum Resolvable Temperature Difference
MSE	Multiple Simulator Environment
NVS/PNVS	Night Vision System / Pilot Night Vision System
PDU	Protocol Data Units
RCS	Revision Control System
RF	Radio Frequency
RWR	Radar Warning Receiver
SAFOR	Semi-Automated Forces
SAL	Semi-Active Laser
SDD	Software Design Document
SDF	Software Development File (Folder)
SFA	Selected Fidelity Analysis
SOW	Statement of Work
SRS	Software Requirements Specification
SSM	Simulator System Module
SSS	System / Segment Specification
STD	Software Test Description
STP	Software Test Plan
STR	Software Test Report
TADS/EOTADS	Target Acquisition Detection System
TBD	To Be Determined
TES	Tactical Environment Simulation
TNE	Tactical and Natural Environment
TRR	Test Readiness Review
TSA	Task Skills Analysis
VSM	Visual System Module
V&V	Verification and Validation
WAN	Wide Area Network
WDL	Western Development Labs

APPENDICES

An appendix entry will be added in the future whenever the ARWA Simulator must undergo verification and / or validation of any enhancements. One appendix for each addition will describe the enhancement and / or software / hardware modification and why the new V&V needs to be performed.